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ABSTRACT

This volume presents the results of literature reviews and research from physical education and related fields on women in sports. The purpose of the report is to present scientific evidence on which to base decisions relating to physical activity and athletic programs for girls and women. One of its main sections deals with the psychological aspects of the involvement of women in sports. Points such as femininity, achievement, family influence, and female aggression are discussed. The other two sections present material on the physiological and biomechanical aspects of the involvement of women in sports. The psychological components of conditioning for stress in sports, temperature regulation, and iron deficiency are investigated. The last section deals with somatotypes of women and the importance of body structure in athletic performance. An annotated bibliography on biomechanics is included in the report. (BRB)

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Women in Sports

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Vol. II

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HEALTH, PHYSICAL EDUCATION AND RECREATION**

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PREFACE

The second volume of *DGWS Research Reports: Women in Sports* presents the results of literature review and research from physical education and related fields for those interested in programs of physical activity and athletics for girls and women. The writing is directed toward all and presented so that those without research and statistical training can read the articles easily.

The Division for Girls and Women's Sports (DGWS) has recognized the need for scientific evidence on which to base decisions relating to programs of physical activity and athletics for girls and women and has charged the DGWS Research Committee with the responsibility of stimulating and encouraging needed research. You will notice on the following page a short article by Marlene Adrian, current Chairman of the DGWS Research Committee, explaining the plan for compiling and disseminating research on females. The implementation of this plan has begun with individuals who have already indicated their area of interest and the kinds of contributions they are capable of making with regard to facilities and equipment. Won't you take time to complete the form provided and become involved as well?

The third volume of the *DGWS Research Reports: Women in Sports* should include the first reports of these research efforts. The third volume should be prepared in approximately two years. The DGWS Research Committee encourages readers to share their interests and needs so that the publication can serve them. The committee also invites articles and research papers for the forthcoming third volume.

Development of a Research Model for Investigating the Woman Athlete

MARLENE ADRIAN

Published research during the years 1960 to 1972 shows meager concern with the woman athlete. Of this research, the major concern for the woman athlete has been with physiological responses and biomechanical aspects. More recently, however, the emphasis has shifted to the psychological and sociological characteristics of the sportswoman. On the whole, research has shown an increased emphasis on study of the woman athlete. In fact, it is the fashionable topic!

However, as evidenced by the first *DGWS Research Reports* publication, many questions remain unanswered. Why does a woman participate in sports? What are the characteristics of women athletes? Is a team sport athlete different from an individual sport athlete? What is the best method of training women for endurance contests? Can women perform equally on teams with men?

This second publication of *DGWS Research Reports*, although providing new information about the woman athlete, will also raise many questions and possibly dispel some theories without replacing them with others. Conferences which were devoted to the study of women in sport were held in 1972 and 1973. Coaches and athletes want to know what research facts have been discovered and what they mean. To date, however, research has been conducted with small samples and seldom have there been more than single efforts of data collection. The testing instruments and procedures used by one investigator usually were not duplicated by other investigators. Therefore, general conclusions or implications to groups other than those tested seldom were possible.

Since more and more girls and women are participating in competitive sports, and participating at higher levels of competition, research findings in this area must have value to the coach and sports participant. As a means of compiling research, and disseminating it into meaningful information, as well as instigating identical research, large scale and longitudinal research are needed. To meet this need, coaches and researchers met in 1972 and conceived the idea for a research model to investigate the woman athlete.

Research interests have been identified under the broad areas of physiological, biomechanical, psychosociological and historical. Subsequent meetings in 1973 are geared to constructing standardized and feasible tests in these four areas, the structuring of regional research teams and the collection of data on college women.

College women were selected as subjects because there is a national structure for competition. Regional and national tournaments provide large populations from many geographical areas. This will enable one to observe trends and characteristics within the nation as well as among different geographical areas. Furthermore, top-level athletes appear to be the ones "everyone" wants to study. It is important that the research conducted with these athletes be beneficial to them. The research model should guarantee that this will happen.

The research will be pertinent; it will be stored in a resource center and become a part of a total data bank on women athletes. It will be made available to coaches, athletes, teachers and other researchers. The model will set forth a longitudinal plan for data collection and provide a method for research duplication at the high school level and other types of organized sports competition for girls and women.

The most important facet of this model is that it is designed with the athlete and coach working *with* the researcher. It is hoped that a synthesis of research and coaching will ensue—in that the research conducted will be applicable to and a direct outgrowth of the needs of the coaches Will you help in this endeavor?

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SECTION 1

INTRODUCTION

SPORTS FOR WOMEN

Barney LeVeau
University of North Carolina
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Women should learn to take sport participation for its true value, and be less concerned about being "masculine." In many articles (23, 27, 35, 39, 57, 58), authors seemed more concerned about defending women's "femininity" than supporting participation in sport for the benefits that can be gained. Sport does not tend to make women more masculine (1). If there is a larger proportion of "masculine" women in sport, it may be because of the physical and psychological characteristics that make one more proficient in physical activity. Thus, as Malumphy (30) found, the participant selects the activity because of her personality; the activity does not shape her personality.

A problem exists as to what is "feminine" and what is "masculine." Apart from the primary sex organs, differences have been found to exist between males and females both structurally and behaviorally, with some overlap. This was demonstrated by Carpenter (8) who attempted to develop a method to differentiate between male and female body build. Therefore, some differences should be presented in order to determine more fully the sports that are best for women.

BIOLOGICAL AND PERFORMANCE DIFFERENCES

Garai and Scheinfeld (17) reviewed many of the important biological differences between men and women. In these studies the average of each trait was considered. In all aspects of strength, males were stronger than females. At age 14, boys were slightly stronger, although the girls were more than a year advanced in skeletal maturation. By age 19, the average male was twice as strong as the average female. Garai and Scheinfeld suggested that this important factor expressed itself in a stronger tendency in males toward restlessness and vigorous overt activity. The studies reported indicated that males were quicker in "normal" movements. Between the ages of 6 and 17, the boys showed a faster reaction speed. The studies revealed that females were much more sensitive to pain and touch—a difference which may have an effect in contact sports. Sapir (45) and Immergluch and Mearini (24) found sex differences in perceptual-motor responses with girls being more developmentally advanced. However, some differences obtained indicated task and response specificity according to sex. Immergluck and Mearini postulated that this may be based on sex-linked behavioral differences.

BODY BUILD

Body composition studies have also revealed important differences. Stuart et al. (54) found little difference during the first 7 years, although girls had a slightly greater fat thickness and total calf width. However, Stuart and Dwinell (53) found that after this age girls had a smaller calf area with smaller relative bone and muscle widths and a larger percentage of skin and subcutaneous tissue. Reynolds and Grote (43) supported these findings. They found these differences to be very pronounced in adolescence and maturity. Broman et al. (6) and Tanner (55) found that all females studied had less dense bones than males. Based on body composition, Reynolds (42) established a fat to bone index for sex differentiation. This index showed a marked differentiation after the age of 13½ years.

Some authors (5:202; 8; 10; 18; 25; 48) have attempted to differentiate the masculine-feminine build based on the shoulder and hip widths. Carpenter (9), however, stated that these measurements were poor predictors of male and female builds due to an approximate 45% overlap found in her subjects. She found the ponderal index ($\frac{\text{height}}{\sqrt[3]{\text{weight}}}$) was the best method of differentiation between masculine and feminine builds. This supported the studies reviewed by Garai and Sheinfeld (17) showing that a height to weight ratio represents an important factor in anatomical differentiation.

PHYSIOLOGICAL DIFFERENCES

Physiologically, the sexes are somewhat different as well. In many athletic activities the cardiorespiratory system acts as a limiting factor in performance. Important differences have been shown in the functioning of this system. Boys were reported (17) to have a greater lung capacity than girls between the ages of 6 and 17. The vital capacity of boys early in childhood was found to be 7% greater than girls', but in adulthood, males had a capacity 35% greater than females'. The female heart rate was faster and the stroke volume was less even when subjects of both sexes were well trained. Anderson (2) stated that differences in maximal oxygen consumption before puberty could not be seen, but after puberty differences were shown to exist. He suggested that this phenomena was probably related more to biological structure than to cultural or social environment.

DeVries (11) listed many physiological differences which may affect athletic performance. Men between 20 and 30 years were reported to have 15% more hemoglobin per 100 milliliters of blood and 6% more erythrocytes per cubic millimeter than women. In capillary circulation, evidence indicated that females have less resistance to breakdowns in the capillary walls from mechanical manipulation. This may be the cause for the greater female susceptibility to bruising.

DeVries (11) indicated that events which depend upon power show the greatest sex difference. This is related to the greater muscular force

produced by males. As far as endurance was concerned, he reported that women during their time of greatest trainability, 20 to 30 years, respond to training with only 50% the rate of improvement of men. A study cited by DeVries showed that after an 18-week training period, the men's capacity was about 1/3 better than that of the women. Heat adaptation in females exacts a greater physiological cost, as was indicated by a threshold for sweating two to three degrees Centigrade higher than that in men. Thus, DeVries suggested that women were inherently less able to cope with hot environments.

There are specific endocrinological differences which affect many of the anatomical and physiological functions of the body. Gilkinson (18) suggested that many physical traits are sex conditioned biologically and that they depend upon the functioning of the primary sex glands. Endocrine secretions may have some effect on behavior as well (4:97).

BEHAVIORAL DIFFERENCES

Behavioral patterns seem to be expressed differently by each of the sexes. Lindrey and Goldberg (28) based this idea on motivational aspects. Using the Thematic Apperception Test, they found that boys had a greater need for aggression. Boys at all ages evidenced more overtly aggressive behavior than girls. Also, boys may have greater need for achievement, although the test did not show this significantly. Girls were presented as having greater needs in abasement, nurturance, and verbal responsiveness.

Garai (16) investigated the needs of each sex. He found that males had a greater achievement drive from early infancy, while females had a greater need for affiliation. Garai indicated that males had the biological drive to master object relationships, while girls attempted to master relationships with people. This supported an earlier study by Goodenough (20) which revealed that at two to four years of age girls showed a much greater interest in people. Goodenough (20) and Garai and Scheinfeld (17) indicated that as early as infancy, boys were more interested in objects and girls were more interested in people and faces. Garai (16) also found that male needs included vigorous physical exertion, motor activity, aggression, independence and dominance. The female needs were sedentary, defensive, safety-oriented, passive and submissive. He stated that this sex difference appeared to be universal.

Studies by Maslow (32,34) and Maslow and Flanzbaum (33) showed that dominant and submissive behaviors existed in various types of primates. The characteristics of the dominant animal were more aggressive and more active. The dominant animal initiated fights, initiated play twice as often, got most of the food, never cringed or fled and took the male position in sexual activity. In most cases males were dominant and were said to play the "masculine role." Females seldom were dominant. However, when a female was dominant, her behavior was observed to be no different from a dominant male. Usually the largest animal

was dominant, but the most important characteristics were aggression and confidence. Dominance did vary in degree.

In humans the degree of dominance was shown by Sharma (49). A cross-cultural study found that in Thai, Indian, American Caucasian, Japanese and Japanese-American societies the males were dominant. Only a slight difference between males and females existed in the population from India. Tulkin et al. (59) found that boys were aggressive, direct and analytic, while girls who were popular were more submissive and conforming. Smith (50) also found that females conformed more readily than males. In relating empathy and aggression in boys and girls, Feshback and Feshback (15) determined that girls demonstrated greater empathy, probably because of the male aggressive behavior.

Other striking differences were demonstrated by Goldberg and Lewis (19). For example, as early as 6 and 13 months, girls showed more need for their mothers. When frustrated, the girls would cry for help more frequently than the boys, while the boys attempted to solve the frustrating problem more actively. The boys played vigorously and were more active than the girls, who were content to sit and play. Garai (16) interpreted this behavior as an explanation of why females could carry out monotonous jobs as long as personal contact existed, and that men needed exciting and challenging tasks much more than women. Garai and Scheinfeld (17) pointed out that many studies indicated that at birth greater motor activity is present in males than in females. This was interpreted as an inherently greater activity drive in boys than in girls.

INTELLECTUAL DIFFERENCES

Just as differences in physical activity seem to exist, differences in mental activity were also observed. Studies by Kostick (26) and Garai and Scheinfeld (17) showed that no sex differences existed in IQ level, but different types of intelligence were found. Boys scored higher on deduction items, ability to transfer, mechanical skills and problem solving. Girls, on the other hand, scored higher on principles, illustrated greater rote and social memory, had greater manual dexterity, demonstrated greater regard for detail and scored better on clerical skills. Boys were found to be better in abstract reasoning; girls were better in practical reasoning. Thus, males appeared better in one type of intelligence and females better in another.

SUGGESTED CAUSES

Although many other anatomical, physiological and behavioral differences may be found, such as resistance to disease (63) and mental health (1), the cause for them has been inadequately investigated. Many authors (5:346; 7; 12; 29; 35; 51; 60) indicated that the behavioral differences were only the result of social and cultural influences. However, Park and Burgess (38) presented an unconditional opinion that the psychical differences of sex were inherited.

Evidence has built up indicating that hormonal effects may represent important factors in one's behavior pattern. Animal studies by Riddle et al. (44), Schooland (46), Beach (4), Harris (22) Young et al. (64) and Tepperman (56) all point toward the important role of the hormones in total body functioning both physiologically and behaviorally.

Beach (4) supported the idea that anatomical and physiological differences between the sexes are caused by hormone secretion. He specifically pointed out that aggression differences between males and females were caused by hormones. The important effect of hormonal control on neural tissue during embryonic organization and differentiation was shown by Young et al. (64). They suggested that early hormonal action was responsible for the establishment of sex-related behavior which was a part of the masculinity or femininity of an individual. However, this behavior was not directly related to the reproductive processes. Tepperman (56) supported this view, but added an important perspective. He stated that the central nervous integrative circuitry essential for mediation of masculine and feminine behavior exists in both sexes. In early embryonic development a sufficient amount of androgen will steer development in the male direction. It affects the reproductive system and crucial parts of the brain. If sufficient androgen is present during a period immediately after birth, physical aspects will not be affected,but behavior will be. Thus, the timing and amount of androgen were considered important. Because of hormonal influence Schooland (46) stated that adaptability, predisposition and perceptual ability of both humans and animals are integrally related. In man, Tepperman (56) suggested that moral, social and cultural influences form a cortical overlay on the basic central integrative structures of this sex-related behavior.

If the hormonal control is as important as these studies show, the environmental effect on "masculinization" of a female plays a much smaller role than that which is currently believed. Thus, whether a girl participates in sport will depend less on her "femininity" than on her basic hormonal makeup.

SPORTS FOR WOMEN

Some authorities have found no important differences in nature between the sexes and others have seen no reason why girls should not play exactly as boys do. However, according to Somers (51) these opinions are definitely in the minority.

The differences between the sexes have been pointed out for one important reason—to show that men and women differ behaviorally, as well as anatomically and physiologically. In general, women's interests and approach to life are different from those of men. However, a value judgment should not be placed on these differences. Because of the differences, whether inherited or developed, women should not completely base their athletic activities around modifications on existing men's sports. These activities have not yet been determined to meet

the interests and the physiological, psychological and sociological needs of girls and women (11).

Metheny (35) spoke of the feminine image in sports. She seemed to be attempting to justify women's sport on the basis of men's sport. She presented socially sanctioned sports which disallowed certain types of activities for women. If these socially unacceptable activities were studied based on the needs of girls and women perhaps they would be found not acceptable because needs are not met, and not because of a social bias. She illustrated that certain activities are not supported by women because of lack of interest. If the activities presented met the female behavioral and/or physiological needs, perhaps the interest would be more evident.

Two approaches may be taken to determine what types of sports should be available for girls and women. One method could be to determine what activities are preferred at each age level. Nevins (37) studied sports for high school girls in Kansas. Forty-seven of 62 schools had an intramural program with most of these having 50 to 75% participation. Volleyball, basketball and tennis were the most popular activities. College girls studied by Baker (3) preferred individual sports to the team sports that were more popular in high school. This was also found by Moyer et al. (36). However, Post and Shirley (41), White (62) and Scott (47) found that the top-ranking activities were similar to those presented by Nevins for high school girls. Although Moore (35) found that college girls favored physical activity and favored participating in sports, they did not participate as much as they wanted. Baker (3) stated that the girls enjoyed sports, but many preferred other activities.

The second approach could be to determine the basic needs of girls and women. The Amateur Athletic Union (1) stated that one important need is self-expression. The ability to express oneself with little restraint can help one maintain good mental health. Numerous studies (1, 14, 63) support the value of sport in meeting the health needs of the female. Contrary to old beliefs, good programs can be of great benefit in improving or maintaining a girl's physiological functioning. Previous studies cited indicated that women have a need for socialization. This need can be met through sport. Girls, in a study by Scott (47), listed socialization as one of the major objectives of physical education in class participation, intramurals and extramurals. Some of this socialization can be attributed to the way women hold extramural activities. Scott's investigation showed that most extramural activities were held in connection with other social events. The practice of serving refreshments after a contest helps to meet this need as well.

Sports definitely have a favorable aspect in meeting a girl's social needs. One-third of the girls studied by Malumphy (31) indicated that dating opportunities were enhanced by sport participation. About 60% stated no difference was apparent. Acceptance of the woman athlete by both men and women peers was reported by Harres (21). Plimpton (40) stated that girls that participate adequately in a sport are much more fun than one who misses the tennis ball every time it comes to her.

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The need to win seems to be less in women than in men. Stafford (52) stated that girls have a lower level of expectancy. The same idea was presented by Malumphy (30). The feelings of winning or losing appeared to be less extreme than those attributed to men. Women were reported to lose and win well. They were more concerned with the level of competition and how well they played. Compared to women in this respect, Plimpton (40) stated that men are more anxious about winning and that because of this, they attempt to force an opponent to commit an error. Women do not have this need to overpower an opponent.

SUMMARY

In summary, women are different from men anatomically, physiologically and behaviorally, although some overlap does occur between the sexes. Thus, women have some different needs that can be met through sport. However, these needs should not be met by treating women as truncated males, as presented by Weiss (61). One approach he mentioned was to deal with women as fractional men. Thus, women and men would be compared and some women would surpass some men. But scaling women in relation to men in terms of physical abilities does not answer the important questions concerning the motivational differences. Each sex seeks self-completion, but usually not in the same way. The common goal is sought and met in different manners. Similar activities do not meet the same needs or have the same importance for men and women. Since women do differ from men, some sports should be designed just for them. The rules should be directed toward what women can do and what they wish to avoid. Adapted versions of men's activities quite often do not meet the needs or fulfill the potential of women. Women can profit from physical activity. Ellwood (13:11) has stated:

> to ignore the differences in original endowment, whether physical or mental, of the two sexes is bound to result in social maladjustment; on the other hand, to discover and use these differences properly is necessary for a scientific organization of human relationships.

It is up to physical educators, men and women, to support the proper type of program for girls and women. This must be done through adequate investigations of the needs to be met and the values to be obtained from the activity.

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SECTION 2

PSYCHOSOCIAL ASPECTS

THE INFLUENCE OF THE FAMILY ON FEMALE SPORT PARTICIPATION

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The structure of the family in our society and the nature of the relationships among its members appears to influence choice or avoidance of activity by females. How much is the concept of family "togetherness" practiced? Are women actually included in family activity? Does the size of the family, ordinal position, or sex of siblings influence girls' participation in sports? How does the pattern of identification with parents, development of affiliative or achievement motives, and sexual identity affect females' choice of sports or avoidance of them? Finally, how can analysis of such information aid in programming of physical education, competitive sports and continuing opportunity for activity for women?

THE FAMILY

The family is defined by Webster as "the body of persons who live in one house, and under one head; and as a group comprising immediate kindred; especially, the group formed of parents and children." Parsons (17:35) points out the difference between the family in the larger sense, the kinship-system common to American society in the past generations, and the nuclear American family, composed of parents and children living at home, the most common form of family structure in our society today. It is, he states, a small and highly differentiated subsystem of society, not an independent society. Parents and children are also members of the larger society. Their familial roles interpenetrate with their roles in other structures of society.

We will center attention on the nuclear family — its composition and effect on the development of children in relation to their participation in sport activity.

Child-rearing patterns vary somewhat with social class or socioeconomic status. Davis and Havighurst (6:709-710) have found that the same differences in practice exist between middle and lower class whites as between middle and lower class Negroes. Two basic interacting systems of behavior, cultural and individual, affect both groups. Middle class parents have a stricter regimen and expect the children to take responsibility for themselves earlier than lower class parents. Children

"most active when young" were reported by their mothers as most frequently fighting and being punished, but happiest — except in the white middle class. In general, expressive, impulsive behavior tended to characterize the happy child. But middle class mothers associated quietness rather than activity in the young with happiness. Perhaps the mothers were happy when the children were quiet, though they may have been inhibiting the development of physical skills.

A study of motor development of Negro infants and its relationship to child-rearing practices, by Williams and Scott (26:168,190), compared high and low socioeconomic groups. Babies from the low group showed greater motor development than babies from the high group. The home atmosphere for the low group was more active, free and uninhibited than the other. These babies have a closer and more manipulative relationship to their environment than babies in the high socioeconomic group, where the atmosphere is more rigid and exacting. This may help to explain the presence of a higher than average proportion of Negro athletes participating in sports.

Three child-training variables — achievement, obedience and responsibility — appear to be associated with games (Roberts and Sutton-Smith, 19:125,131). But games tend to differentiate between the sexes. Those chosen by girls emphasize strategy and chance; those favoring boys stress pure physical skill. Games of pure physical skill are the least complex and most motor of the games, thus they incorporate less conflict than the symbolic, complex games the girls play.

Social class differences are evident in the development of masculinity and femininity. Lower class members tend to define masculinity and femininity more narrowly than do members of other classes. Education, particularly, affects this concept. The more educated the parents, the more readily they seem to tolerate deviant behavior in their daughter (3).

For all strata of society, however, the concepts of masculinity and femininity are clearly delineated. Desirable qualities for males are independence, aggression, achievement-orientation. Desirable qualities for girls are affiliation, nurturance, dependence and passivity. These qualities are so definitely prescribed by our society that Bardwick considers lack of motivation toward achieving them to be pathological (3:162).

Sports and recreational activities involving physical skill are positively identified with the male sex role and negatively associated with the female sex role in American society (10,24). Therefore, the culturally defined sex role is an important factor in study of sport participation.

Parent-child relationships. It is apparent that parents serve as models of behavior with which their children can identify. Contemporary psychologists are questioning the traditional view, however, that girls simply identify with their mothers and boys with their fathers. Johnson (9:319) points out a reciprocal role relationship that is functional at a particular period in the child's development. The development of personality in the child involves his making a series of successive identifications with increasingly specialized and differentiated roles. Parsons' (16) dis-

tinction between the mother's expressive role and the father's instrumental role is preserved within this understanding of the child's identification process.

Bardwick (3:138) supports the theory that children normally identify with both parents rather than one. She differentiates between personal and positional identification — between a nurturant, expressive relationship and one which is largely instrumental. While the mother may be both loving and instructive to her daughter, the father's role is generally more valued by the culture, therefore by the daughter. Competition and achievement are part of the male role, which can become attractive to the girl who enjoys a warm, unambivalent relationship with her father — especially if her mother is rejecting or rejected by her.

The important factor in developing femininity in girls (and masculinity in boys), according to Mussen and Rutherford (14:244-245), is self-acceptance on the part of the mother, rather than encouragement of her daughter's participation in feminine activities. Fathers of highly feminine girls, however, played a significant role in encouraging femininity. It seems that the girl's family plays a more forceful and direct role as teacher and socializer than the boy's, probably because behavior appropriate for boys is more clear-cut and well defined.

Patterns of sexual identity for girls. Bardwick (3:140-141) stresses the "bisexual" nature of identification for middle class American girls. The culture values masculine roles, goals, and success, she points out. And the preadolescent girl is permitted, even encouraged, to succeed in competitive academics, sports, or leadership roles — preparation for the professions. These, she will find at age 12 to 14 or so, are "masculine." The need to achieve comes into conflict with the need to affiliate and must be resolved in some way. Assertions of femininity by female competitors are an example of this (such as frills on tennis costumes). But the basic conflict is in role definition, not "packaging," and must be evaluated intelligently.

The need is evident for consistency in role expectations for girls. The successful competitor has developed self-esteem based on such achievement, recognized by parents and peers. When parents decide such achievement is a threat to their daughter's social life and eventual marriage, they push the feminine role. This often results in the girl's retirement from serious competition because of fear of success, confusion over how she should handle her desire to excel, and fear of failure (7).

An essential difference between boys and girls age 14 through 16 is pointed out by Douvan and Adelson (3:148-149). The boys studied consistently viewed their relations with their families as combative. Major battles were over independence. The girls, in contrast, remained compliant and continued dependency relationships with their families. Bardwick interprets these findings as evidence of the primacy of the affiliative goal of the adolescent girl. She is competitive, but in the social sphere rather than in the academic, vocational or sport worlds.

Siblings. In addition to cultural expectations, sibling relationships have an important influence on the development of masculininity-femininity. Three significant variables in this relationship are *birth order* (or ordinal position), *sibling-sex,* and *family size.*

Several studies have been conducted on the effect of birth order on the development of masculinity-femininity and personality characteristics. Children in one-, two-, and three-child families are differentially affected by the reinforcements in sex-role learning (20). Both siblings and parents have an influence on personality development. In fact, in the large family expectations of siblings eventually may outweigh those of parents (5).

Rosenberg and Sutton-Smith (21) have studied family interaction effects on masculinity-femininity development in detail. They found that the two-child family has a distinctive structure that varies with the sex and birth order of the children. In general, where both children are of the same sex, they reinforce appropriate sex-role learning. Where they are not of the same sex, in the boy-girl family, they react to "isolation" by compensatory heightening of their own sex-role characteristics. The boy becomes more masculine and the girl more feminine. This effect varies somewhat with birth order, however, as is demonstrated in the following study.

Undergraduates at Brockport attempted to use the Rosenberg-Sutton-Smith format above to study family interaction effects on the femininity of physically active women (18). They gave the Gough Scale of Femininity to "active" and "inactive" college women. The participation factor was not significant, possibly because the measures of activity may have been inadequate (class and intramural participation), but the results on the femininity scale corresponded closely with those of Rosenberg and Sutton-Smith (21). Females with a sister were most feminine and fathers with two daughters and males with a sister were least feminine.

Results of a study of ordinal position and sex-role identification, also by Rosenberg and Sutton-Smith (20), revealed varying dynamics of position in the family. The only child who is a boy is the most anxious of 17 groupings studied and the girl is least anxious. She rates above average on masculinity scores and below average on femininity scores, which should make her the best potential sports competitor. Among girls, as the family increases in size, anxiety in first borns tends to decrease, and appropriate sex-role identification is reinforced by the presence of like-sex siblings.

The relationship of sibling status to sissiness and tomboyishness in children five to six years old from white, urban families, was studied by Koch (11:242-243). She found that both "sibship" and spacing was important. Second born boys with sisters were more sissy than boys without sisters; whereas, when the sibs differed by more than four years in age, the relationship was reversed. No significance was found in the variables related to tomboyishness in girls, though girls with brothers more than two years older have a tendency to be relatively tomboyish.

In a study of ordinal position and sibling-sex status related to the degree of sport and recreational participation, Landers (12) tested female education and physical education majors. While activity did not prove to be a significant variable in results of a series of tests, "post hoc analyses" showed that education majors who had younger brothers participated in significantly more masculine rated sports and had a lower femininity rating than those with younger sisters or older brothers. The author speculates that this may be related to a certain "power advantage" (e.g., physical size and maturity) which may permit her to interact in sports with her younger brother longer than the girl with an older brother. Results also showed that girls with younger sisters were significantly underrepresented in the physical education group.

Landers (12) also checked ordinal position of male sport participants. Males with older sisters were overrepresented among high school baseball players and participated in a greater number of sports than did males with brothers or with no siblings.

In a study extending Landers's research on sport participation of women, Acelson (1) checked the frequency of representation in ordinal position of women athletes. The most masculine-conceived sport (track and field) had an overrepresentation of females with older brothers. This finding is similar to that found for physical education majors by Landers (12). In feminine sports, however (gymnastics, figure skating and synchronized swimming), females with younger sisters were overrepresented.

The influences of birth order, family size, and sex differences on risk-taking was the subject of a study by Jamison (8). He found that family size was the important variable, rather than ordinal position and sex. Children of both sexes and different ages from larger families accepted more risk than those from smaller families.

A widely quoted study by Nisbett (15) is concerned with birth order and participation in dangerous sports. Results demonstrate that first born sons are less likely than later borns to participate in dangerous or high-risk sport. The sample studied included college students and professional ball players. The author quotes from a study by Shachter (22) which revealed that first borns have a greater fear of electric shock, therefore of physical pain, than later borns. He also cites Torrence (25), who reports that fighter plane pilots who were first born children were considered less effective than later borns. In large families, however, first borns are more likely to participate in dangerous sports than in small families. Also, they participate in nondangerous sports (baseball, basketball, crew, wrestling, track, swimming, tennis, fencing, golf) as frequently as other family members. Dangerous sports which were avoided by members of the college sample were football, soccer and rugby. One wonders what a study of mountain climbers and sky divers might reveal.

Nisbett's study was used as a basis for experimentation by Longstreth (13:154) who devised a scale of participation or nonparticipation in physically dangerous activities. At one end of the scale (1) was: "physically very conservative at age 12, tended to avoid dangerous activities and

rough games." At the other end of the scale (7) was: "physically very daring at age 12: never turned down a physical challenge: always ready for rough-and-tumble with plenty of bruises to show for it." Results revealed that 59% of the first borns rated themselves at the conservative end of the scale (score 1-4), while 35% of the nonfirst borns did so. This relationship held for both sexes but was significant only for males. The author "favors the usual argument," as an explanation of the first-born fear of danger, that mothers are more emotionally involved with first born than later borns. Further, the anxiety is stronger with sons than daughters because of the cross-sex relationships. However, since increase in family size also increases the likelihood of the first born participating in dangerous sport (15), it would seem that the relationship with the mother tends to vary with family size.

Theoretical explanations of the effect of ordinal position and sibling-sex variables. Landers attempts to relate theoretical explanations for the kinds of family socialization processes which children of different ordinal positions and sibling-sex statuses experience to participation in sport activity. His results are interesting, if uneven, since it seems he does not have all of the important variables. Family size, for example, is not one of the variables included in the hypotheses, yet is considered by some students of the subject to be the most important variable determining participation in dangerous sports.

The theories discussed by Landers are modeling theory (sibling-similarity and sibling-opposites hypotheses), structural balance theory and conformity hypothesis. Of these, the modeling theories are represented in the research included in this paper, and will be discussed briefly.

Of the theories cited, Landers states, the sibling-opposites hypothesis, which is based on a conflict model, seems to be the most plausible explanation for the greater participation of males with an older sister. The sex role conflict of the males in the presence of a majority of females is apparent in the studies of Rosenberg and Sutton-Smith (21) as well as Landers (12) and Acelson (1), discussed above.

The sibling-similarity hypothesis, a positive modeling theory, is supported by the work of Rosenberg and Sutton-Smith (20, 21), in which females with brothers, particularly older brothers, have lower psychological femininity scores than females with sisters. These findings are not statistically significant, however, and are contradicted by other findings. Therefore, Landers concludes, further investigation by means of in-depth interviews is needed to determine the degree and specific type of modeling process involved in socialization. It would seem, also, that the interaction of variables additional to those studied must be considered.

The relationship between sex-roles and sport participation in our society becomes apparent when we consider the positive identification of the male sex role with sports and the negative association of the female sex role with sports. Qualities needed for competitive games are acceptable in males. Socially acceptable activity for females is aesthetic (dance, skating, gymnastics) rather than competitive. Females may be

achievement-oriented, however, if it does not interfere with affiliation or their social life. Tenley Albright points out that the average person considers figure skating to be gentle and graceful. Actually, skating demands a great deal of physical strength and endurance. Perhaps such aesthetically pleasing sports would be judged as less "feminine" if their physical demands were better understood (2).

Kagan and Moss (10:117) found that the correlations in the dependency behavior variable of girls — in childhood, at adolescence, and in early adulthood — were higher than for any other behavior dimension that was measured. This indicates that the culture permits a range of dependent behavior in girls that is not tolerated in boys. This differentiation begins in childhood in our society, as it does in 110 cultures studied by Barry and associates (4:332). There is a widespread pattern of greater pressure toward nurturance, obedience and responsibility in girls, and toward self-reliance and achievement striving in boys.

In middle class culture, however, *rigid adherence to sex-role behavior is weakening,* and this is correlated with educational level. Rosenberg and Sutton-Smith (20) found that girls were more masculine in their game choices in 1960 than they had been in 1930. But lower class behavior tends to be more traditional than is middle class sex-role behavior.

Bardwick (3:152) anticipates increasing numbers of ambivalent feminine girls or achievement-oriented girls among the middle class. Such girls suffer from fear that men will not accept them because of competitiveness, anger over the dominance of men at work, and anxiety about the place of women in the home. If such emotional energy can be organized constructively and included within our feminine role concepts, the possibility exists for creativity within sports as well as within the professions and other areas from which women have been largely excluded.

SPORT

Opportunity for sport participation depends on the availability of facilities, the possession of the necessary skill and some confidence in one's ability to perform. As we have noted, males in our society tend to develop aggressive, competitive characteristics. They frequently develop physical skills to go with this self-concept. As they mature they have a background of participation going for them. Girls, in contrast, are expected to develop quite opposite, social skills. They enter adulthood rather unequipped, usually, for sport activity with their families — unless, of course, they are able to hire instructors.

Stone (23:415) points out the dilemma of the middle class American woman. She rarely exhibits expertise in matters of sport, yet senses the need to participate in order to share a common family interest. Upper stratum women participate in club sports with their families and lower class women carry on what sport activity they are permitted independent of family members. But middle class women are caught between a togetherness ethic and inadequate preparation in sport concepts and

skills. To make matters worse, middle class men look outside the home for sport companions almost twice as frequently as the women do. This means the wife is left behind with unresolved conflicts.

Implications. The need for development of a broad understanding of the meaning of sport in our society is becoming more apparent each year. For most Americans leisure time is increasing. The need for activity, for physical and mental health, is debated frequently by doctors of medicine, psychology and sociology. But the issue is not likely to get off the ground until our population is able to experience enjoyment of activity from childhood through maturity, and to develop an appreciation for the human values of competitive and recreational sport for both men and women. Spectator education could be undertaken along with study of the meanings or significance of sport. Conversations about sport, as well as watching it, should be recognized as a meaningful part of social life for women as well as men.

Just how recreation programs and facilities could be provided for all levels of society is a matter for professionals to research. But economically poorer societies than ours have provided incentive as well as facilities for participation. Television coverage of China recently showed table tennis tables in the communes, as well as young and old doing calesthenics. Workable programs like Head Start and Upward Bound need to be developed in other areas. Perhaps recreation could be one of them.

Finally, research projects need to be developed to explore the relationship of birth order, sibling and family relationships, size of family — for boys and girls — in representative areas of sport, such as individual, team, aesthetic, combative and high-risk. Sport educators and planners of recreational programs need to know what kinds of activity to provide for differing socioeconomic classes, for boys and girls, men and women, older individuals, for urban and rural populations. Some beginnings have been made in disciplines related to sport education, which could be used as models by researchers in our field. An example is Nisbett (15) who took Shachter's work on anxiety and fear of physical pain (22), and developed a research design to test first born boys in relation to high-risk sport activity.

Inquiry is needed into the *specific needs of the female related* to physical activity and sport competition. Perhaps her needs are actually human needs, shared by both sexes, with few exceptions. We need to determine female capacities and limitations — physical and emotional. What activity or competition is appropriate in light of the factors above? Vigorous as well as graceful? What does femininity actually mean? Is the present role definition accurate, or does it need revision? Mussen and Rutherford (14) suggest that self-confidence and satisfaction with one's role are more important in the female model with which young girls identify than "feminine" characteristics. Perhaps the dependent, passive role is overrated.

What kinds of programs can be designed to meet the needs of girls and women? Early enjoyment of activity, provision of continuous oppor-

tunity for meaningful experience in sports, and a setting which confirms a woman's self-image rather than one which detracts from it seem important. Supplementary services for women who need them may be called for, such as child care, transportation, flexible hours and schedules. Opportunity to learn skills and to acquire an understanding of sports which their families and communities find important should be provided for women as they age.

We may not want to adopt communism or tribal ritual (any more than we already have) to develop our rationale for sport. But we do need a unified, coherent system of meanings or contributions of sport participation, physical or vicarious, based on scientifically verified information. Females must be included in a program based on human values which would permit all to participate somewhere along the sport continuum.

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ADOLESCENT CRISIS: SPORT PARTICIPATION FOR THE FEMALE

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Physical education and psychological literature abounds with the glories of athletic participation. Reviewed studies show significant relationships between positive self-esteem, social acceptance, and athletic prowess, especially in adolescent boys (24). The same may be true for the female (16). Female athletes have been shown to possess favorable personality traits of self-confidence, self-control, endurance, tough-mindedness, stability, autonomy, happy-go-luckiness, intellectual brightness, conscientiousness, and perseverance (18, 19). With these positive elements of sports participation, why does the female drop the pursuit of sport?

Most girls drop athletic endeavors in early adolescence about age 15 or 16 (4:46; 21:32). In the physiological sense, girls and boys increase in strength and endurance in a parallel fashion until age 13 (1:39). Boys continue to develop physical skill, strength and endurance to adulthood, but, because of lack of participation, these physical factors in girls peak and deteriorate long before attainment of the physical potential. Athletic girls have followed the pattern of the boys, i.e., they continue to develop strength and endurance to adulthood (1:39).

Historically, women were excluded from sports because of the alliance between sports and war. Warriors participated in sports to ready themselves physically and psychologically for battle. Since women did not go to war, they also did not participate in athletics. Women were relegated to the roles of cheerleader, homemaker, and child-bearer. Since infant mortality rates were high, large families valued, and birth control methods unknown, women were married early and almost always in some phase of pregnancy. The ritualistic and brotherhood factors of sports participation served to exclude women from athletic pursuits. The low status of women and other societal pressures prevented women from taking an active part in sports.

In the last century women were released from many of these restrictions, but still were not permitted to engage in virogous athletic endeavors. Vigorous activity was thought to be harmful to the "womanly parts," especially the parts involved with childbearing. These notions have been dispelled (22:37), and in fact, vigorous activity may decrease

the time and intensity of labor and speed up the recovery in childbirth (20:49-50). Sport rules have been modified to allow safe female participation. Protective devices such as shin-guards and breast protectors have been used to insure the safety and welfare of the female athlete.

Although the physical dangers of active sports participation are about equal for girls and boys, the girls are usually more fearful of physical harm. Many factors may account for this fearfulness. Since parents are more protective and restrictive with a female child, she is more likely to be afraid of getting hurt (4:55). Girls have less pain tolerance (23:82) and may avoid athletics to avoid possible injury and pain (or possibly even the pain associated with vigorous participation — breathing hard after running, muscle soreness, etc.). Also, since girls are more narcissistic (2), the danger of scars and broken teeth deters more girls than boys from engaging in sports (10:21).

In early childhood, boys and girls are more alike than different (2). Through trial and error, or stimulus-response, boys are rewarded for active and aggressive behavior, while girls are punished or ignored. Girls follow expectations by becoming more passive. Girls help Mommy cook dinner and are given a doll for Christmas; boys help Daddy fix the car and are given a baseball glove. Boys play Little League and Midget Football; girls play house. Even at this young age when the physical sex differentiation is minimal, the girls are gently pushed into feminine passivity. Is it any wonder that young girls rarely develop an active interest in sports?

Because of this passive role adoption, the young girl may not experience the same level or kind of movement that the young boy may experience. She is less active in the vigorous sense, less experienced in the skilled sense, and less trained in the mechanical sense. Lack of movement experience and the consequent lack of a movement vocabulary may contribute to the lack of sport involvement exhibited by girls (13). Along the same lines, if the young girl has not developed a movement vocabulary she may be very uncomfortable in a sport situation, and thereby may avoid it. She may not participate because of feeling inadequate from lack of strength (13). She may also lack the skill needed to succeed and will therefore not participate for fear of failure. If she has tried and failed she is less likely to try again (2:173). If she does try again, she is more likely to fail again (6:216, 236).

Kagan and Moss (12) found children of both sexes more alike than different, except on dependency behavior. The culture permits and encourages a range of dependent behavior in girls and not in boys; consequently, boys are forced to become autonomous and independent. Girls are more dependent for a longer period of time, feel less adequate, and are less able to cope by themselves (2:117). Girls tend to be extrinsically motivated. They tend to achieve for affiliative reasons and to strive for attention, affection, and reinforcement from adults in childhood, peers in adolescence, and husbands in adulthood (2:175). This need for extrinsic approval hinders the expression of aggressive tendencies (2:130), which may negatively influence sports participation.

There are other notable factors that may account for the lack of sport involvement in the female. She simply might never have the opportunity. The facilities may not be available (boys usually have preference!). The girl may participate in a wide range of other activities and not have time to pursue sports (21:32). She may just hate to change for activity (21:32). Lack of funds may also contribute; the first area to feel a budget squeeze is the girls' sports program.

Despite the problems, some girls do enter the sports arena. Although rarely applauded, the preadolescent female athlete is tolerated by society to a greater degree than the sissy male. With extrinsic encouragement from older brothers, physical educators, coaches, and, sometimes, fathers, the young girl may participate and experience success in athletics.

It is easy to see why young girls do not enter the sports world, but, once they have entered and experienced success, why do they drop sports? As adolescence approaches the sex differences become more pronounced. Girls begin to look more like the women they will become and boys like men. The adolescent male may fulfill his cultural sex-role prescription by being more "manly" through early maturation, mesomorphic somatotype, and athletic prowess. Although more intrinsically motivated, his peers accept, encourage, and reinforce this manliness. "Boyhood friendships are more likely to be based upon similarities in physical activity ..." (4:54). The boy's social self and his sport self are in harmony, i.e., in consonance.

As the girl approaches adolescence her status becomes increasingly linked to her femininity. Her friends are not based on similarities in physical activity (4:54), but are based on similarities of social activity. Because of the presence of the secondary sex characteristics, she becomes more aware of her femaleness. Early maturation does not enhance self-concept as in the male. Early maturation may cause her to be listless, submissive, and to lack poise. The early maturing girl, in contrast to the early maturing boy, may have difficulty in peer relations and may lack popularity, prestige, and leadership (6:123). Adolescent girls value the ectomorphic somatotype; the mesomorphic girl athlete is likely to possess negative feelings concerning her body type (3).

Participation in athletics and exhibition of athletic prowess may create a far greater problem for the adolescent girl. As previously stated the adolescent girl seeks attention and reinforcement from her peers, especially the boys. Sherriff and Harres (21, 7) found that although both sexes believed that girls should be given the opportunity to compete, both also agreed that athletics will increase a girl's "mannishness." Bardwick made some pertinent comments concerning this role identity crisis for the female adolescent athlete:

> If the girl has had many years in which she has been permitted to participate in what will be perceived as masculine activities, and to the extent that success in these activities, especially individual competitive ones, form a core part of her self-esteem, it will be difficult for her to assume a clearly feminine sex-role identity and a preference for the feminine role. (2:143)

> The girl's early participation and possible success in activities which will later be defined as masculine provide the underpinnings for ... a "bisexual" identification ... the normal girl will identify herself as female and can perceive herself as feminine but she may have also learned that she is capable of achieving success and self-esteem in the competitive and aggressive modes of ... athletics. (2:141)
>
> ... the motorically active, preadolescent girl will achieve status through competitive sports. Later, in adolescence, especially when teenagers are cruel in their demands for stereotyped conformity of behaviors, she will undergo a deep crisis.... (2:104)

This crisis that Bardwick depicts is caused by the disharmony between the girl's sport self and her social self. Dissonance further exists between the components of the sport self and the social self. There is dissonance between sport aggressiveness and feminine passivity; between dominance and deference; between assertiveness and submissiveness; between vigorous activity and inactivity; between toughness and gentleness; between mesomorphic body build and ectomorphic build; between frilly dresses and warm-up suits; between fancy hairdo and crop cut; between time demanded for practice and time for other activities; between sport model and ideal self; between independence and dependence; between being mannish and being feminine.

A person can not possess dissonance for very long; it must be resolved (5). Many girls resolve the conflict by dropping out of sports participation, i.e., eliminating the sport self from the selfhood. This may be the reason that so many women feel that they have not fully developed their potentials (2:155). Girls learn to achieve for affiliative reasons and they may learn not to achieve for the same reasons, i.e., they may fear success (11) and drop sports.

Other girls may resolve the dissonance between their sport self and social self by eliminating the social self. They may merely withdraw from social situations and any other situation that requires the feminine role (9:297). Or, they may extend the sport self into the social self. They become aggressive, assertive, tough, independent, unempathetic, domineering, and generally more "manly" than the norm in all situations. This type of dissonance reduction may lead to exhibition of the "typical jock" stereotype. As Harris put it: "... they do not care and thus have 'nothing to lose' " (8).

Others cope with the dissonance in another fashion. Not willing to give up either the sport self or the social self, these girls are able to be the sport self in a sport situation and the social self in a social situation. They are as secure of their femininity whether dressed in an evening gown or a sweatsuit. There is no dissonance or conflict, for these women are cognizant of and proficient in both roles. Maslow (15) might term these women "self-actualized" female athletes.

Layman (13) supports the application of Festinger's dissonance model to female sports participation (5). She believes that women athletes reduce dissonance by participation in individual sports rather than team

sports, by dropping athletic endeavors, or by perceiving sports as not in conflict with her self image, i.e., either ignoring the problem or awareness of both roles.

The difficulty of dissonance reduction by acceptance of both selves may depend on the specific sport activity. Although feminine females are observable in all sports (9), society is more accepting of the female tennis player, golfer, swimmer, and skater than of the female jockey, basketball player, and softball player (7; 13; 21). Society should not dictate the type of sports participation for women. As Malumphy puts it:

> Skill and victory should not and probably do not dissolve, negate, or detract from femininity ... it's not the sport, or the skill, or the score, it's the participant that determines whether her participation enhances or detracts from her femininity. (14)

To facilitate dissonance reduction some athletes bring ostensibly feminine adornments into the world of sports (17:124). The bouffant hairdos of the track girls, the frilly bloomers of the tennis players, the flowered suits of the swimmers, the culottes of the golfer are all parts of the movement to show society that the woman athlete can be athletic and feminine. Some state that these ostentatious adornments help convince the participant of her femininity. Perhaps, a better view would include the convincing of both society and themselves.

It is this author's contention that girls drop the pursuit of sport, not because of physical inability or innate lack of predisposition to athletics, but because of societal and cultural pressures that begin with the family, extend through the school environment and peer pressure, and end with the internalization of the norm — physical inactivity or passivity. The youngster's selfhood is poured by the family, shaped by the school environment, molded by peers, and solidified by societal reinforcement. Girls who defy societal expectations by continuing to participate in athletic endeavors resolve dissonance by ignoring their femininity or by realizing and fulfilling both "selves."

Despite the many problems, more and more females are entering the sports world. From 1960 to 1968 the number of women participating in the Olympics rose from 500 to 800 (17). Increasingly, women are permitted to enter the formerly all male worlds of business, the professions, and sport. The question is: can she rise above the early subtle cultural conditioning to take advantage of these opportunities? If this societal trend of greater behavioral latitude for both sexes continues, the female athlete eventually will not need to resolve dissonance and will not concern herself with "how to be an athlete" or "how to be feminine" or "how to be a feminine athlete," but she can focus on "how to be."

IMPLICATIONS FOR PHYSICAL EDUCATION

1. Girls, as well as boys, should have the opportunity to develop a movement vocabulary.

2. Every child should be helped to derive some degree of success in sports.
3. There should be more equality in terms of facilities and budget.
4. Teachers and coaches should be aware of the female athlete's conflict so that they can point out the situational specificity of behavior.
5. Girls should be helped to realize that they can be athletes and feminine.
6. Lifetime and individual sports offerings should be increased.
7. The feminine image (dress, language, voice, etc.) should be stressed.
8. The number of coeducational offerings should be increased. If girls depend on reinforcement from boys, the boys must be educated to see that girls can be feminine athletes.
9. A broad base intramural program should be built so that strength is not the overriding factor.

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FEMININITY, ACHIEVEMENT, AND SPORTS

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Women physical educators often express concern that few women out of the total population really become involved in sports. At this point, society does not seem to feel that highly competitive sports are the feminine thing to do. The purpose of this paper is to review briefly some misconceptions about women's participation in sport, to discuss the feminine sex-role, and to see if the achievement and competitive drives and aggressiveness which are often considered necessary to be successful in sport are compatible with the feminine role.

A big misconception pervading women's sports until recently has been the belief that women would either be harmed by vigorous activity, or that they simply were not capable of performing at a high level. In 1924, William Tilden wrote about tennis:

> Women have not the necessary speed of foot, the reach, or the stamina to stand the strain of a net attack for two long sets, much less for three. This has been conclusively proved by the great champions. (47:124)

Today, this statement has been disproved by the modern women champions who are highly conditioned and who play an attacking game.

The participation level of women in sports has definitely increased through American history. Holliman (17:163-171) describes the recreational roles of men and women in colonial America. There were distinctive differences between the recreational goals of the sexes: men were distinguished by performing athletic feats; women won recognition through manual dexterity, especially needlework. Halsey (13) traces the development of women's sports through the acquisition of feminine independence in practical situations, namely, the moving of the frontier and the Civil and World Wars, when the women had to take over civilian occupations to free the men to fight. Thus, by the early 1900s, more people were developing the idea that since all participate in the competitive activities of life, then all should benefit from the biological, mental, social, and moral benefits of athletics (11, 12). In 1938, Carpenter, studying women, showed that although a "masculine" build was favorable to the development of power and muscular strength in sports, that motor educability was more important for success (6). Today, Jokl echoes the

medical profession's opinion that the female is biologically capable of participation in sports (20).

PHYSIOLOGICALLY FREE, BUT CULTURALLY BOUND

Physiologically, then, the female is freed by science to participate in sport. However, cultural roles still prevent her from participating freely. Broom and Selznick (4) state that in Western society, the difference in masculine and feminine roles is associated with sharp differences in temperament. The female is seen as naturally non-aggressive and passive, and the male is seen as naturally aggressive and active. They cite Mead's study of three primitive societies which suggests that these temperamental sex differences are not universal, but are cultural.

Complicating the American acceptance of the belief that the female should be more submissive and less able, Ulrich mentions the American values of aggression and competence, and the problem of women in defining their sex-role when "the cultural concept of the female role negates the cultural concept of the American personality" (46:22). Metheny feels that although the old role of the female as the protected one may seem to be an advantageous one, it also "deprives us of the privilege of exploring one's own human potential for growth and achievement" (31:153). Perhaps this is the deprivation that the women cited by Friedan (10) felt after following the Feminine Mystique: preparing for marriage, rearing a family, and then still feeling dissatisfied with life.

That the American culture values grace and femininity over bravery and strength for women (16) is shown by the fact that some sports are generally accepted for women, while others are not. Metheny (31:49-52) has classified sports according to their acceptability for women from data on attitudes expressed by American college women. Those which are acceptable involve projecting the body through space in aesthetically pleasing patterns, using force through a light implement, or overcoming the resistance of a light object with skill and manipulation. Unacceptable sports involve body contact, application of force to a heavy object, and projecting the body through space over long distances. That these feelings cut across the cultural lines of the countries attending the Olympics suggests to Metheny that the clue to what is acceptable may lie in the different ways the male and female use their bodies in the sexual act: the male is seen as the controller, using a direct application of bodily forces, while the female is seen in a more passive role, receiving and nurturing new life.

The Higdons quote Hein from the American Medical Association's Department of Health Education.

> We value in this country certain attributes in men: bravery, strength, capacity to compete in vigorous sports. But in a woman we value social graces and femininity more. These are not necessarily lost in vigorous sports, but some sports are more graceful than others. (16:322)

This feeling is echoed in Albright's comment that the qualities of gentleness, consideration for others, and the protective maternal instinct are foreign to the mock fighting, aggressive, body contact sports (1:55). But she also says that if people realized how much physical strain is involved in skating or dancing, these "gentle" sports would also be considered unsuitable.

Studies often show that individual sports are more popular than team sports are for women (14, 34, 41). About half of the teenage girls in the sample to which Sherriff refers (41) felt that participation in intense competitive programs led to the development of "masculine" mannerisms and attitudes. However, half of the collegiate golfers and tennis players in Malumphy's study (27) actually felt that their feminine image was enhanced by their participation. This difference could be caused by the age difference of the subjects in the two studies, the fact that those in the latter group were the participants, or that golf and tennis may be more of an accepted part of the upper class, to which others aspire. Since individual sports seem to have a favored position for American women, this author further speculates that since sports such as tennis, swimming and golf are often learned and played in a social male-female setting (28), they may be rated more "feminine" because they receive the social approval often desired by the female. (This need will be discussed later.) Team sports are usually taught in the school setting, in sex segregated classes; this allows less understanding, and perhaps less approval, from people not involved in a girls' gym, namely the males.

According to Metheny (31:180), problems with half facts about what is feminine might stem from our acceptance of averages as norms, when, in fact, the male and female populations involve overlapping ranges. Neal reminds us that

> Men and women *both* are capable of kindness, aggression, physical and mental self-discipline, strength, and endurance. Men and women *both* can be strong, can endure, can run, jump, laugh, and cry ... It is time society banished the pejoratives "tomboy" and "sissy." (33:20)

DEVELOPING SEX-ROLES

The review of the literature so far indicates that some sports are considered masculine and some are considered feminine by various people. But what is meant by "feminine"? The next step is to look at the development of the sex-role identity of females to see just what characteristics might be internalized as "feminine."

Johnson (19) discusses Parsons' reciprocal-role hypothesis. The expressive role player is oriented toward sensitivity and responsiveness to the attitudes of others, while the instrumental role player is oriented toward success in the working world, viewing interaction as the means to an end. Parsons' theory suggests that the main mechanism of the development of sex-role identity in both males and females is the internalizing

of a reciprocal role relationship with the father. Both sexes are nurtured by and identify with the expressive (representing nurturing, unconditional love) mother during infancy. The father differentiates his roles toward his male and female children. He encourages instrumentalism (characterized by the objective outside world) in his son by being more demanding toward him. He is less demanding of his daughter, and praises her for such things as looking pretty. The life task of the girl, then, is to shift her expressive attachment from her mother and father to a more mature expressive attachment to husband and family. The boy, in addition to shifting his expressive attachment to an adult female, must also learn an entirely different orientation, instrumentalism, for he must cope with the nonfamilial environment.

This model has held through experiments. Johnson refers to studies done by Sears and herself which indicated that the mother was perceived by both sexes to be expressive, while the father was felt to be expressive by his daughters and instrumental by his sons. Another study by Johnson showed that the more expressive college girls described their fathers as being attentive and protective, while the least expressive girls described their fathers as being distant, cold, and critical. Rosenberg and Sutton-Smith (39) found that the fathers' scores on the Gough Scale of Psychological Femininity varied as a function of the sex of their children (more female children, more feminine a response), while the mothers' scores did not vary.

If boys and girls are oriented toward different roles, then the sexual differences should show in children's play. Cratty (8) notes that males are more active and gain leadership through physical endeavor, while the females engage more in manipulative activity and gain status through verbal behavior. However, the girls seem to exhibit a wider range of games. Brown (5), using the It Scale for Children, found that boys expressed a stronger preference for the masculine role than the girls did for the feminine role. He attributed this to the greater status of the male in American society and to the greater latitude that the girl has to choose play activities characteristic of the opposite sex. Since the stick figure doll in the It Scale might have been seen by all the children as a masculine figure, causing the girls to choose more "masculine" items, Ward (47) developed a toy preference test in which the children chose their preferences from pairs of pictures of toys. In this study, the girls still had a greater variance of play choices than the boys. Rosenberg and Sutton-Smith (38), using a check list to test game preferences in children in grades one through eight, found that boys had fewer games that differentiated them from girls than girls had to differentiate them from boys. In comparing their data to items in a 1926 study by Terman, they found that a shift in games had occurred in the direction of the females, as Terman's study had more items which differentiated in favor of the boys. Thus, Rosenberg and Sutton-Smith note that, while the female role perception in children's games has extended since 1926, the masculine role perception seems to have become confined. Sutton-Smith, Rosenberg, and Morgan (44), using a play scale to study changes

in play choices of 190 children between grades three and six, found that at about the fourth grade level, girls begin to choose a wider number of masculine and feminine games than do boys.

Comparing the results of cross-cultural studies and child rearing practices, Roberts and Sutton-Smith (36) suggest that anxiety over child rearing practices is reflected in involvement in expressive models, such as games. Building on an earlier study by Roberts, Arth, and Bush (35), they found relationships between obedience training and games of strategy, between responsibility training and games of chance, and between achievement training and games of physical skill. In the earlier study (35), games of chance also seemed to be models of interaction with the supernatural. Thus, one receiving more training in achievement (or in the instrumental role), i.e., boys over girls, may be more likely to seek out games of physical skill to express mastery and achievement in sport.

Landers (24) used Roberts' and Sutton-Smith's hypothesis to discuss the results of his study of the psychological femininity of physical education majors as compared to education majors, in which he used the masculinity-femininity scale of the MMPI and the Gough Scale of Psychological Femininity. On both scales, the physical education majors had significantly lower femininity scores than the education majors. However, when individual item clusters were analyzed, education majors differed in the feminine direction in only two categories: Restrained and Cautious and Religious beliefs. Landers suggested that

> From this it can be argued that those who are more successful in games of physical skill (e.g., males more than females and women physical education majors more than education majors) may become more confident through their successful encounters with their achievement models (e.g., games of physical skill) and thereby express their confidence in a way which could be considered boasting or exaggerating. Likewise, games of physical skill may attract and/or develop individuals (through their successful experiences in these games) who are less reliant upon mystical or benevolent powers and more reliant upon their own individual initiative. (24:169)

Another factor which affects the child's sex-role preferences is the sex of his siblings. Koch (23), studying "sissiness" and "tomboyishness" in children from two child families, found that boys with an older sister tended to be more "sissyish" than the other boys. Though not significant, there was a strong suggestion that girls with an older brother were more likely to be "tomboyish" than those with an older sister. Rosenberg and Sutton-Smith (40) did a study which confirmed Koch's suspicion, and suggested that the presence of opposite-sex siblings tends to decrease self-sex preferences, while the presence of like-sex siblings tends to reinforce the self-sex preferences in two and three child families. Sutton-Smith and Rosenberg (43) also found this to be true in their 1965 study of college sophomores. Landers and Luschen (25) compared 56 physical education majors with 146 education majors on their frequencies

within one and two child families and ordinal position categories. They did not find any meaningful relationships except that the first child females with one younger sister were underrepresented among the physical education majors.

DEVELOPING A PASSIVE ORIENTATION AND A NEED FOR SOCIAL APPROVAL

Extending the theory that females have a more expressive orientation, one might also expect them to be more passive. Some researchers feel that females are originally prone to passivity. Kagan and Moss state that there is evidence of a link between passivity and muscle mass during the early years (21:81). Bardwick (3) and Millan (32) state that females are less likely than males to be mesomorphs, and thus may be more constitutionally prone to passivity than the males, who have more active mesomorphs among their sex. A study done by Sugarman and Haronian (42) indicated that a more sophisticated body concept and mesomorphy were closely related to athletic participation, while ectomorphy was related to low athletic participation in their sample of college age males.

Once prone to passivity, the female is socialized into being more passive. The cultural stereotype of the passive female and active male is reflected in studies of the preferred body stereotype preferences of the sexes. With the Sheldon body types in mind (ectomorphic—thin, endomorphic—fat, and mesomorphic—muscular), one would expect the body ideal of the male to be mesomorphic and the body ideal of the female to be ectomorphic. This is what the studies indicate. Sugarman and Haronian (42) cited the Brodsky study of male medical and dental students which ranked the social desirability of stereotypes, with mesomorphs rated highest, then ectomorphs, and endomorphs lowest. Caskey and Felker (7) reviewed a study by Kurtz, which found that college males preferred the male body types which were mesomorphic, while college women preferred the female body types which were ectomorphic. In their study, Caskey and Felker found that this preferred stereotype emerged as early as second grade. Their elementary school girls, regardless of their own body type, viewed the pictures of the ectomorphic girls most favorably, attributing the most favorable personality traits to them. Completing the picture for that age group, they cited a similar study of elementary school males by Staffieri, in which the mesomorphic body type was seen most favorably. The endomorphic body type was seen least favorably in the above studies.

Going back to the expressive-instrumental dichotomy, the theories seem to support that, while the female is allowed to continue her dependence, the boy is pushed into independence at an early age. Kagan and Moss note that passive and dependent behavior carry constant cultural disapproval for the boy, but not for the girl (21:269). The earlier review of game choices indicated that girls were able to choose more sex-inappropriate games than the boys seemed able to choose.

Besides the push of boys into an instrumental behavior, other factors may operate which more or less force the males to choose satisfactions independent of social approval — factors not usually operant on girls. Maccoby (26) notes that girls mature slightly sooner than boys in articulation, verbal skills and physical development. Thus, when children enter the first grade, the girls are slightly ahead of the boys in the motor and perceptual abilities which might enable them to be successful in school. Maccoby notes that these differences usually disappear by fifth or sixth grade.

Though the differences disappear, the orientation toward learning might not have. For example, if boys are slightly behind the girls in development, they will be less likely to be able to coordinate movements to write clearly and may receive less constant praise than the girls for doing assignments well. Perhaps this aids the male's push into independence and the female's early training in working for praise and social (the teacher) approval. Boys, less likely to do a beautiful assignment, would have to look elsewhere for satisfaction — an area independent of the teacher's praise. Maccoby suggests that the conformist tendencies of girls

> ... help them to excel at spelling and punctuation — the kinds of performance for which there is only one socially prescribed right answer. But for higher level intellectual productivity, it is independence of mind that is required — the ability to turn one's back on others at least for a time, while working alone on a problem — and it is this which girls, from an early age, appear to find so difficult to do. (26:35)

Some interesting results have been obtained in relationship to the social experience domain of the Kenyon attitude inventory. A study by Kenyon (22) suggests that the passive orientation of girls and the active, independent orientation in boys is reflected in their attitude towards physical activity. Kenyon found differences between high school age males and females on his Attitude Toward Physical Activity Inventory which were constant across Canada, Australia, England, and the United States. He found that females had higher scores on the domains of physical activity seen as a social experience, for health and fitness, as an aesthetic experience, and as catharsis, in that order. High school males scored higher on activity as an experience in the pursuit of vertigo, as an ascetic experience, and as an experience involving chance. One might note that the dimensions of sport ranked high by the females in Kenyon's study were oriented more toward the social and the beautiful, while the perceptions of activity which interested the males represented internal controls, risk and independence.

Youngen (48), studying the choices of West Coast college women on the Kenyon scale, used only those women who had scored in the highest and lowest quartiles of the Marlowe-Crowne Social Desirability Scale, a scale purportedly showing need for social approval. She found similar

results in subdomain rankings of both groups. Although similarity of the two groups was not expected in attitude toward physical activity, both groups ranked pursuit of vertigo and aesthetic highest in meaning and ranked physical activity as a social and as an ascetic experience lowest. Her results might be explained by the status of sports for women. Those girls needing social approval would not necessarily get it from participation in sports, because sports do not generally carry a high status for women. Thus, they would not have a good attitude toward sport as a social experience. Girls having a low need for approval probably would not be looking first for qualities in activities which would further social experience, and so might not be looking for social experience in sport either. It would have been interesting to see if the girls scoring in the middle 50 percent of the social desirability measure scored similarly to those girls in Kenyon's study. However, this was not intended as part of Youngen's design.

A study by Alderman (2), using the Kenyon scale to study Canadian athletes at the 1967 Pan American Games, seems to indicate that as sport involvement and skill reach their peak, the values seen in sport become markedly similar for men and women. Alderman notes that

> Both the male and female groups rated physical activity as an *aesthetic* experience as having the strongest meaning for them, with *social experience* and catharsis in the number two and three positions. *Fitness, vertigo,* and *ascetic* were rated equally less strongly by both groups. (2:4)

This author's conclusions to the above studies are limited, of course, by the variation in the age levels and geographic areas from which the samples were drawn. But they do show the complexity of the problem of relating traits and experiences to women's attitude toward physical activity.

THWARTING OVERT AGGRESSIVENESS

One behavior which is more consistently punished in females than in males is aggressive behavior (21:98). Thus, Bardwick feels that girls withdraw not from aggression, but from the more obvious direct physical aggression (3:125). She feels that girls are really more aggressive than the studies usually show, but that they are not overtly aggressive, because their interpersonal dependence makes them feel guilty when ignoring society's negative feelings toward aggressive behavior for girls. Her hunch was proven in studies using the prisoner's dilemma, which eliminated the interpersonal factor by not having the experimenter and the opponent visible to the subject. The women were found to be more aggressive toward each other than the men were. Bardwick suggests that the early verbal behavior of the girls enables them to develop more sophisticated (and less punishable) methods of coping with aggression. These include

withdrawal of friendship, verbal slams, the use of adult intercession, gossip, tears, and somatic complaints (3:125, 134).

Thus, aggressiveness is a feminine trait; however, it is not expressed physically by the female, while it is by the male. Perhaps, as the female sublimates her aggression into a less physical expression, it becomes less obvious to her that certain actions are, in fact, aggressive behavior, and she may link aggressiveness with overt, physical aggressiveness, and couple that with masculinity.

As the girl reaches adolescence, she is more likely to develop a more intense reaction against aggressive behavior (21:99), as she tries to mold her behavior in a way which she thinks will appeal to the opposite sex. Friedan notes that at this time, girls tend to drop special interests to spend time learning how to appeal to the opposite sex (10:65).

PROBLEMS IN ACHIEVEMENT

The achievement orientation of the female seems to involve both a fear of failure and a fear of success. This lessens the achievement motive and perpetuates passive dependence. Kagan and Moss found that the young male adolescent will continue striving despite the possibility of failure, whereas the girl will be more likely to withdraw. They attributed this to the fact that culturally, the girl has the option to withdraw, while the boy does not (21:130). According to Horner (18) the girl may also withdraw to avoid success. In our society, competitiveness is a valued trait for the male, but not for the female. Bright women are thus in a double bind — if they fail, they do not live up to their potentials; if they succeed, they will not live up to the social expectation of the feminine role. So what does the woman do? According to Horner, those girls having more anxiety about success go into the traditional "feminine" careers — housewife, teacher, nurse — to avoid competition with males. Friedan notes that many of the female college students of the late 1950s equated seriousness with unfemininess, and they did not allow themselves to become interested in their studies, fearing that it would interfere with marriage (10:144).

Matthews and Tiedeman (29), in a cross-sectional study of 1,237 females in early adolescence, adolescence, and young adulthood, found that the life styles of girls were related to their attitudes toward career and marriage. They found a drop in career commitment from junior to senior high school, perhaps, they suggest, because of the imminent possibility of marriage. They state

> It appears that many girls and women structure their lives on the premise that males view the female's use of her intelligence with distaste and that it is therefore wise to accept this situation if one wishes to marry ... Parents usually state a wish for girls to be able to earn a living, and yet they are fully as concerned that their daughters be marriageable. This leads many parents to caution their daughters

not to be overly competent in their careers and to seek a "suitable" marriage partner. (29:382-83)

That many of the female's expressed interests are influenced by the societal temperament is shown when characteristics of the male-female dichotomy are removed from the situation. Although the number of subjects was relatively small, a by-product of a study of power styles and driving by Roberts, Thompson, and Sutton-Smith (37) is meaningful. They studied self testing attitudes toward driving, an activity which uses physical skill and strategy. Questions concerned the preference of cars with good pick-up, the degree of enjoyment of driving, the enjoyment of speed, and attitudes toward traffic flow and passing. Although there were differences in the degree of self testing in driving according to age (youngest and oldest drivers more self-testing), there were no significant differences according to sex. Evidently, since driving is one of the few activities involving physical skill and strategy in which it seems to be accepted (and necessary) for the female to participate, the female is free to experience driving in her own way. Perhaps the female's expressed orientation (to society) and real orientation (competitive style) differ.

Studies involving masculinity faking on a vocational scale show this contingency of the female's attitude to society's attitude toward occupations. McCarthy and McCall (30) administered the Strong Vocational Interest Blank twice to 40 nuns: the first time with regular instructions and the second time, instructing them to answer as a man would. Their results indicated that differences could occur on the FM scale, as well as on other scales of the test, if the subjects desired to fake the results.

Farmer and Bohn (9), critical of the procedure of suggesting that the subjects pretend they are men, studied the way women could "fake" the Strong test if the subjects were instructed to pretend that men like intelligent women and that raising a family is possible for a career woman. In the second testing, the 25 single and 25 married, middle aged, business women scored higher on career related scales. In a sense, being told that men like smart career women either freed the women to respond in that direction, or encouraged their interests to shift in the direction toward what men like. There was no significant difference in the results according to the married versus single status. Farmer and Bohn state:

> ... the fact that these women were older and had already made their career commitments would suggest that the effect of set on young girls would be even greater. (9:230)

FREEDOM FROM THE CULTURAL BIND

Thus, we find that the female's constitutional tendency toward passivity is reinforced culturally to develop an individual who finds her identity in the opinions of others, who molds her sex-roles according to the culture, and who is thus as afraid of success as she is of failure. However,

there are an increasing number of girls who are becoming successful in business and in sports. A look at the factors which release these females from playing the traditional sex-role might suggest how these successful individuals are developed. One factor, the influence of siblings, has been discussed. For example, a girl who has an older brother may be more likely to choose masculine play activities (such as sports).

The influence of social class seems ambiguous. Bardwick mentions that sex-typing is more vigorous in the lower classes (3:151). This agrees with the findings of Kagan and Moss, which indicate that the higher the education level of the family (used as the socioeconomic determinant), the less likely the individual will adhere to orthodox sex-role traits (21:171). However, in the two Landers studies (24, 25) which compared physical education majors with education majors, the social status of the physical education majors was lower than that of the education majors. An analysis of variance (25) showed that subjects scoring in the top and bottom quartiles of socioeconomic status did not differ in sport participation and femininity ratings. Perhaps the disproportionate number of lower socioeconomic class students in physical education reflects the places where sports are experienced. Upper class girls would be more likely to learn sports in a club setting and would learn to see them as recreation. Lower class girls, who would be more likely to experience sports only in the school situation, might be more likely to associate them with the serious educational institution. These girls may then aspire to become a teacher of sport in that institution. A girl having her best sport experiences in a club situation may aspire to continue to be a *member* of the club (by entering a well paying occupation or by marrying well), rather than to work *for* the club members.

Both Kagan and Moss (21:221) and Veroff, as reported by Bardwick (3:176) suggest that maternal hostility, exhibited in a critical or rejecting attitude of the mother toward the child, is a factor in the development of a need for achievement in the female. This would fit in with the reciprocal-role model which was discussed by Johnson (19); perhaps the mother, being critical, rather than expressive, pushes the girl into an instrumental orientation. Also, a critical upbringing (or achievement training) could, using Roberts' and Sutton-Smith's model (36), induce the girl to engage in physical activity as part of her mastering the conflicts resulting from her achievement training.

The above factors involve somewhat exceptional childrearing backgrounds. It is possible, according to Maccoby (26), that girls who so deviate and are independent may pay the price in anxiety. This anxiety could even lessen the degree of achievement of which the individual is capable. Thus, all factors considered, the most important factor in the female's ability to leave healthfully the stereotyped female role and be successful in all aspects of life as well as sport might be her level of self esteem. Harris states

> In general, females who take the risk and participate in such [competitive] sports are either secure in their role as a female so that

> participation does not strike them as a threat, or they do not care, and have 'nothing' to lose. (15:2)

Bardwick agrees, stating that

> the lower a person's self esteem the greater the anxiety and the greater the response to assume a role ... an exaggerated conformity to the stereotype of the sex roles in behaviors and personality traits is probably indicative of anxiety about one's core masculinity or femininity. (3:155, 166)

Bardwick sees the ability of the 30- to 40-year-old woman to return to a career as an outgrowth of the stableness that she has achieved in the accepted role of wife and mother and in the fact that her affiliation need has been fulfilled.

It would seem that the route toward developing an independent, self-assured woman would involve her understanding some of the types of things which have been discussed in this paper. As she began to understand what is fact, what is cultural, and what is myth, she would have a basis from which to understand and select the roles she would like to play. Bardwick does not feel that dependence has to be detrimental to a female's success, or that independence has to be detrimental to her feminine role.

> In women, healthy dependence means a sensitivity to the needs of the persons who are important to them, which allows appropriate nurturant or supportive behaviors ... Independence in achievement behaviors results from learning that one can accomplish by oneself, can rely upon one's abilities, can trust one's own judgment, and can become invested in a task for its own sake. (3:115)

In addition, some factors might be built into the physical education program to increase the understanding and social acceptability of women's sports for the women themselves. Sex-stereotyped movements might be discussed in basic movement units. For example, is there such thing as a male or female movement or a male or female sport? Aggressiveness might be discussed in terms of its obvious (movement) and subtle forms. More attempts might be made to have coeducational classes where the activity permits it. Where it does not, attempts should be made to get the boys interested as spectators, to give them more understanding, and, it is hoped, to generate active approval of sports for women from those people to whom the young women look for approval — the males.

THE WOMAN'S DILEMMA

Thus, the woman's dilemma: living in an achievement oriented society and possessing real feelings of aggression, she is discouraged from being overtly aggressive. Her continued expressive and dependent roles orient

her to external social motivations for her behavior. At the same time, she is allowed a large range of activity choices, stretching across the male-female continuum, in which the "masculine" choices are more tempting in light of American values. If she chooses masculine activities, she may look "unfeminine" to society, and, since she has a need for the approval of others and a vague idea of her feminine role, she is more likely to conform to the stereotype of femininity, for that at least defines a role which society will accept.

Those women who are successful may have either thrown off concerns about being feminine, or may have developed an independent and positive sense of self-esteem as women that makes them "able to elect their roles and enjoy their freedom of choice" (3:205). One of the roles which they can elect is that of the sportswoman.

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FEMALE AGGRESSION AND SPORT INVOLVEMENT*

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Although the experimental research in psychology suggests that the female is passive and nonaggressive, one has only to view the Roller Derby a few minutes to come to another conclusion. The assumption that the male model of aggression is the only form and the fact that this standard has been used to assess aggression in the female has led to perception of generally lower levels of aggression in the female.

While girls are not likely to demonstrate overt physical aggressive behavior typical of the boys, they tend to display their aggression in other ways. They become "tattletales," use verbal slings and arrows, and withdraw friendship. Bardwick (1) suggests that girls are less disposed toward aggression, especially the overt physical type; she also suggests that culture reinforces acceptable aggressive behavior in both boys and girls. Margaret Mead concluded that human nature is almost unbelievably malleable after studying the behavior of three New Guinea Tribes. Her observations suggested that many, if not all, of the personality traits that we have called "masculine" or "feminine" are no more linked to one's sex than the clothing, the manners, or the type of hair style that a society endorses for either sex at any given period.

Although each culture supports its own concept of masculinity and femininity, there are cross-cultural consistencies; in most cultures the female is less likely to engage in overt physical aggression than is the male. However, these commonalities of behavior should not be interpreted as being sex-linked as there are biologically normal individuals in nearly all cultures who do not fit the expected, traditional behavioral role. According to Mead, the evidence points overwhelmingly to societal shaped sex-role learning as the determinant of masculine-feminine differences in aggression as well as of most other behaviors. Bardwick also supports this contention.

Findings of the research from the 1930s to the 1960s support, with great consistency, the effectiveness of the societal shaping of aggressive behavior in both sexes. In 1964 Kagan (4) commented that it was difficult

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to locate a study in which aggressive behavior of the male was not greater than that of the female. However, keep in mind that the investigator gets out of the study what he puts into it; in other words, when one is using the traditional masculine overt physical form of aggressive behavior as the standard, girls will always appear less aggressive because of the conformity to society's expected female role behavior.

It is difficult to discuss one behavior at a time without considering the interaction of many other behaviors, especially in the discussion of aggression. Sears (9) reported in 1961 that sixth grade girls scored higher than boys on prosocial aggression and anxiety about aggression. It was concluded that the anxiety was a result of the conflict between the desire to be aggressive and the awareness of the appropriate sex-typed behavior. As expected, the boys scored higher on antisocial aggression. One interesting correlation was observed — both the boys and girls who scored higher on the femininity test also had higher scores on the prosocial aggression and aggression anxiety tests. Conversely, those who scored lower, both boys and girls, on the femininity test also scored lower on the antisocial aggression measures. Sears' interpretation was that more girls than boys will score higher on the femininity measure and will use the more socially appropriate form of aggression, that being prosocial. However, those boys who score high on femininity measures will also use the more feminine form of aggressive behavior.

Other investigators have reported that girls who have a high need for achievement and who are not anxious about being successful in their endeavors have low levels of guilt about expressing aggression toward authority figures or concern about being socially accepted. These are the exceptional females and they contrast strongly with other teenage females who were high on sexual anxiety, affiliation needs, and guilt feelings about aggressive behavior. As expected, boys were higher on aggression, independence and autonomy. In boys, aggression tended to be an independent characteristic whereas in girls, aggressive behavior correlated with need for independence and competence and for an identity dependent in part upon achievement. Socially, these goals are more characteristic of boys in terms of expected role behavior; however, females who are successful in athletics and other achievement oriented tasks also display these characteristics.

Kagan and Moss (5) reported that dependency was a stable personality trait among females and aggression was a stable trait for males. Aggressive behavior for the preadolescent male was a good predictor for aggressive behavior as an adult but they could not predict adult aggressive behavior in females on the basis of childhood behaviors. Kagan and Moss suggested that this was because of the cultural socialization of aggressive behavior in girls. They also observed socially sanctioned sublimation of aggression in girls. Achievement and recognition behaviors for both boys and girls were stable characteristics; boys who were fearful and girls who were bold both aspired to intellectual mastery as adults. In their sample population participating in a longitudinal study, it became clear that the intellectual competitiveness developed from quite different

personalities in the male and in the female. It appeared that both sexes who perceived themselves to be at variance with the expected societal sex-role behaviors pursued intellectual mastery for resolution of their conflict. Among the females, Kagan and Moss reported one major cluster of intercorrelated variables which included competitiveness, achievement, intellectual mastery, masculine interests, less social anxiety and a reluctance to withdraw from stressful situations. The personality profile of these females was more closely related to the male model on these dimensions. The female used her intellectual or professional pursuits as the place where she could express her abilities, independence, competitiveness and aggression with less likelihood of alienating others. Perhaps this is the type female who frequently is found pursuing athletics as well.

Heilbrun (3) found the relationship between aggression and sex-role identity was similar in the older population as well; he found that older females who had a feminine sex-role identity were also less aggressive. Greater femininity in both the male and the female was associated with greater anxiety about aggression.

Recent research suggests that males and females may have similar aggressive needs; however, males can express their aggressions much more directly without a sense of guilt. Females are more likely to feel conflict and guilt, and therefore are likely to inhibit any direct overt expression of aggression. Bardwick suggests that "to measure the true levels of aggression in males and females, one must include verbal aggression, interpersonal rejection, academic competitiveness, gossip, deviation from sexual standards, passive aggression, manipulation of adults with power, withdrawal, tears, and somatic complaints — as well as fighting, hitting, and biting" (1:134). What then is the relationship of aggression and sport involvement? More specifically, for the purposes of this paper, what is the role of aggression in the female's involvement in sport? Evidence suggests that aggression may be an acquired behavior resulting from differential training and experience. Therefore, individual differences will be observed among human beings, and females (as well as males) will demonstrate varying levels of aggressive behavior. If sport involvement and competitive experience can provide a laboratory for teaching the control of aggressive behavior, as some suggest, then it becomes as important for the female to share in these experiences as for the male.

Behavioral research on the female athlete indicates that there are more similarities than differences in terms of the behavioral profile of male and female athletes. The females in general appear more aggressive than their counterparts who do not involve themselves in competitive athletics; they are more like the males in terms of their aggressive levels. Scott (8) has said that with respect to instrumental aggression, females may be just as competitive as males; therefore, those women who enjoy competition should have the opportunity for participation.

In terms of evaluating aggression among females, researchers have begun to look at aggressive behavior in specific situations rather than

in generalized terms. When female athletes are asked to describe themselves as they view their behavior in everyday situations, they do not differ from the norms of other females. However, when asked to describe themselves in competitive athletic situations, they demonstrate much more aggression and are more like the male athlete than the female norms. These findings have been replicated in several studies producing the conclusion that, for the female, aggressive behavior, along with many other behaviors, is quite specific to the situation in which the female perceives herself to be. One study of female athletes who participated in individual sports found an increase in perceived aggression from the social situation to the competitive situation significant at the .01 level (7). A second study of female high school basketball players also found a significant increase in perceived aggression when they viewed themselves in a competitive situation (10). A third study approached the problem from a different perspective (6). Female athletes were categorized into two groups — 1) competitive structured athletes who played a sport which was coached, rule governed, and with the object being to win and 2) the competitive creative athletes who had to compete for selection into membership but who then were involved in preparing for a performance such as a dance concert or a swim show. When asked how they described themselves as high school females, they did not differ from one another, nor did they differ when asked to describe themselves in their respective competitive situations. However, there was a significant increase in perceived aggression in both groups. When the structured athletes were asked to describe the creative athletes and vice versa, both groups thought the other to be significantly more aggressive in social situations; the creative group thought the structured group was much more aggressive than they perceived themselves to be. The creative group also perceived their faculty sponsor as significantly more aggressive than the structured sports athletes viewed their coach.

Although this type of research raises more questions than answers, the implications are interesting. It appears that the female athletes who participate in the more socially acceptable athletic pursuits have greater difficulty in accepting competitive athletic behavior as being appropriate feminine behavior. Also, female athletes appear to have greater cognitive dissonance in terms of how they actually perceived themselves and how they feel they should be, especially when concerned with aggression. In other words, they have a gap between what they think they are and what they think they are expected to be. This perception of dissonance can cause psychic discomfort to the point that the athlete withdraws from sport involvement. The association of aggression with masculine behavior appears to influence the perception of this dissonance in the adolescent female. Interestingly enough, adult females who are participating in competitive sports do not perceive themselves as being any more aggressive than those who do not compete in sports. Perhaps they have resolved the dissonance that adolescent females display (2).

Although similar studies have not been conducted with male athletes, there are indications that much of their behavior may be specific to

the athletic situation and not their consistent behavior throughout everyday involvements.

In general, female athletes exhibit higher levels of aggression than their non-athletic counterparts. This can be explained in several ways. First, since we get out of behavior assessments what we put into them and since the male standard of aggression has been the one utilized in most instruments, with the definition of aggression including such behaviors as being competitive, stubborn, assertive, and an independent thinker, female athletes, in general, will exhibit higher levels of aggression than other nonathletic females. Second, as long as competitive sports are associated with masculinity and with aggressive behavior, females who enjoy these activities will be expected to be more "masculine" because their interests will tend to categorize in this fashion.

As Bardwick suggested, aggressive behavior in human beings needs to be explored from a much broader perspective and considered as much wider behavior response in terms of understanding aggression. Further, focus upon the demands being made within the situation, specifically within the competitive situation, is needed to understand aggressive behavior. This approach appears to be especially valuable in studying female aggression. That an individual is able to meet the demands of a situation by being competitive, assertive, persistent, independent, etc., and that being "successful" requires this type of behavior, does not indicate that this behavior is typical of every situation.

While females may have a different genetic disposition to agonistic behavior, this sex difference, if it does exist, does not apply to object centered aggression. Since this is the major type of aggressive behavior observed in competitive sports, both the theory of aggression and the theory of sports should be the same for both sexes, according to Scott (8). Since some researchers and some evidence suggest that females may be as aggressive as boys in many respects and that they are more hostile and aggressive than most experimental procedures reveal, competitive sport involvement may be just as important for her as for the male. This is especially so if sport experiences do serve as training situations for the control and mastery of aggressive behavior.

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THE PHYSICAL EDUCATOR, MISS OR MRS.?

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Walk into a women's physical education department at the college level and glance down the roster of staff names. In most cases the number of "Misses" far exceeds the number of "Mrs." Since this occurrence is so common, there must be some explanation other than coincidence. One might say that this is true of professional departments in other fields, but physical education seems to outrank them all. Why are there so many single women in college physical education? Is there some truth to parents' fear that their daughter majoring in physical education will end up at thirty without a husband? Are physical educators meant to be categorized along with others:

> economically and professionally successful women are aggressive elitists; heterosexually committed women are cowards and deserters; happy mothers and Marxist women are fools and fifth columnists; lesbians are sick; white women are racists; black women can't wait to walk behind their man; middle-aged women wear hats and gloves; young women carry spears and throw bombs. (3:89)
>
> P.S.: Professional physical educators are single.

Davis and Olesen state that there is little known about women who are professionally involved in male-oriented fields: "as for the small number of women who are actually studying or working in them, very little is known; judging from some scattered, small-scale studies, it appears that a comparatively large proportion are unmarried" (4:342).

The purpose of this paper is to investigate the reasons why female college physical educators are so often single; it is an attempt to answer the question so often heard: "she's so attractive in so many ways — how come she isn't married?" The possible explanations involve sorting out myths, culturally conditioned concepts, and facts.

A GROUP PROFILE

College physical educators were once physical education majors, which is a starting point for a group profile. There is a substantial amount

of literature indicating that physical educators are of a "type" all their own.

Thorpe (18) compared senior physical education majors, graduate students, and teachers to each other and to a normative group using the Edwards Personal Preference Schedule. She found some significant differences among the groups, but a much greater difference was found when the total group was compared to the norm. The physical educators were significantly higher than the normative group in deference, order, dominance and endurance; they scored lower than the norm on autonomy, succorance, nurturance, heterosexuality and aggression.

A similar study was conducted by Roberts (13) to assess the characteristics of professional male and female physical educators. Using the Cattell 16 PF on a large sample of physical educators who had attended the national AAHPER convention, she concluded that male and female physical educators were more like each other than the general population. Female physical educators were assertive, dominant, persistent, tough-minded, controlled and composed. The women in administrative positions were especially reserved, intelligent, confident and experimenting.

Kane (8) used six criterion groups with 100 subjects in each group to compare specialist male and female physical education students to the general students. He administered the Cattell 16 PF and 16 dimensions identified by Fleishman and through multiple discriminant analysis found that women specialist physical education students differ significantly in personality from the general women students. In general, they were tough-minded, stable, conservative, and extroverted.

The literature indicates a distinct physical education personality which may be necessary for success in the field. It appears that female physical educators have adjusted to a sports role: they are dominant, confident, intelligent, assertive, tough-minded, controlled and composed. On the other hand, they appear to be low in such traits as succorance and nurturance. The suggestion is that a woman physical educator is a self-sufficient and independent sort of person from the time she first enters the profession as a major. And, as pointed out by Kagan and Moss, "high dependent girls become high dependent women, and low dependent girls become low dependent women" (1:117).

Most female physical educators have performed to some extent athletically. Often, one is asked: "what is your sport?" In looking at those traits necessary for success in sports competition, more dimensions may be added to the personality profile of the female physical educator.

Vanek and Hosek state that competitors involved in sport have a high need for achievement: "on the whole we can expect a higher need for achievement with top sportsmen than with the average sportsmen or normal population" (19:89). This statement is not exclusive of women: "sports require commitment, endurance, concentration, and physical ability. These are traits of the highly motivated person — evidenced by women as well as men" (6:10).

The choice of physical education as a scientifically-oriented career may in itself be an indication of a person's need to achieve. Bardwick (1)

cites Sundheim as reporting that the highest motives to achieve were found in women majoring in the atypical and difficult choice of science.

It seems that need for achievement is an important dimension of the physical educator's makeup, especially if she has competed for a good part of her life as many have. In a review of the literature on need achievement and personality traits by Taylor (17), the following factors are listed as being positively related to those individuals with a high need for achievement: able to handle anxiety, a feeling of self-worth, ability to conform to authority, less conflict over independence-dependence, and a realism of one's goals. Therefore, these qualities might also be added to the female physical educator's profile.

To complete the picture presented by physical education professionals, a consideration of the masculinity-femininity issue must be touched upon. Are females in physical education more masculine than feminine and therefore avoided by the male sex? Is a "jock" image scaring away all the men?

It doesn't take a perceptive person to realize that female physical educators are often stereotyped in a certain image. As one girl stated as she closed the door to sports participation: "the girls in it seemed so funny; none of them combed their hair or seemed to take care of their clothes" (7:22). Another statement referring to female competitors drives the point home vividly: "the Russian girls look like a lineup of the Jets without Joe Namath ... he's too pretty!" (2:135).

Certain studies would indicate that female physical educators are less feminine. For example, Landers (9) found when comparing 43 female physical education majors to 43 education majors on the MMPI masculinity-femininity scale and the Gough Scale of Psychological Femininity, that the physical education majors had significantly less feminine scores than the education majors.

Some commonly held cultural connotations of women being involved in sport are not exactly supportive of females. Adjectives associated with competition (aggressiveness, strength, tenacity, self-confidence ... etc.) are also associated with masculinity, so that women who are "good" in sports are characteristically masculine. A statement by Scott verifies this belief in that females "who do totally dedicate themselves to sport are invariably labeled as being masculine by the male controlled sports establishment" (14:57).

On the other hand, research may be found to stabilize the precarious position that females in athletics find themselves in. Essentially, femininity and attitude towards sport is a more positive one than is generally presented.

Simon (15) investigated the relationship of the masculinity-femininity image between female athletes and non-athletes and found that femininity and achievement need are not related. A study of female college swimmers and male Olympic swimmers by Ogilvie (12) using the Cattell 16 PF and Jackson Personality Test reinforced his premise that there is no loss of feminine traits most valued in our culture because of com-

petition; the female swimmers had fine personalities as well as being good competitors.

In the course of studying personality characteristics of females who competed in national and intercollegiate athletic events, Malumphy (11) found that two-thirds of the women felt that sports participation enhanced their feminine image. Moreover, three-fourths of the girls felt that the "significant others" in their lives supported their participation.

So, what can be said about female physical educators and their supposedly masculine image? The distinction that needs to be made is most appropriately shown in a study by Layman (10). Using 113 entering freshmen as her subjects, she administered the Opinion, Attitude and Interest Survey which includes a Masculine Orientation Scale. The physical education majors were higher on the scale than girls in other majors, but not significantly higher than art majors. Furthermore, none of the women scored above the median score for men. This certainly is not the same as being masculine.

Therefore, several clarifications are needed in the femininity-physical education issue. First, from the standpoint of body structure, it is likely that a person in physical education may be strong and may have a somewhat boyish build since this is conducive to successful physical participation in activity. This does not mean that she must or will be mannish in her gestures or thinking. Second, she may have a tendency towards masculine interests in that she enjoys those activities typically associated with men. It might be that she does present a slightly "less feminine" image than other girls because of her interests, personality traits, and the physical demands put upon her. But to say that she is more masculine than feminine is a gross misconception. Naturally there are some exceptions, as found in that one female who manages to "walk, talk, and eat" like a man, and perhaps this is where the generalized stereotypes take their root.

THE CULTURAL CONTEXT

To summarize and present a general profile of the college female physical educator, one needs to conglomerate the characteristics discussed previously into some kind of a whole. Realizing that there are exceptions to any generalization, one could say that she will exhibit many of the following characteristics: independence, self-assertiveness, competitiveness, need for achievement, aggressiveness, dominance, persistence, tough-mindedness, desire to experiment, confidence, intelligence, and extroversion.

It is when this "personality" is placed into the context of our culture that one can begin to perceive why the college physical educator so often spends her life as a single person. The pressures, expectations, and roles expected of her from so many sides, plus her own combination of personality traits, place her in a position which is difficult to resolve: "paradoxically, while females must not succeed, when they do succeed

at anything, they have still failed if they're not successful at everything" (3:89).

Women, according to Horner, are afraid to succeed. After administering the Thematic Apperception Test to 90 girls at the University of Michigan, she found that the girls associated success in women with loss of femininity, social rejection, personal or societal destruction or some combination of the above (5:51).

Moreover, women often resent other successful women. Chesler goes so far as to say that "women, even more than men, seem to be threatened by those personal traits in a woman which are 'different' or 'male' like" (3:110).

As for the men, Horner also found that they were afraid of successful women. Harvard men who were administered the TAT responded with all types of bizarre answers towards the following cue: "Anne finds herself at the top of her medical class." Typical responses were: "Anne is not a woman. She is really a computer," or "Anne is in a wheelchair and studies for medical school" (5:53).

The product of these two attitudes towards successful women contaminates many women's drive to excel so that those who fear success enter traditional roles such as nurse or housewife, while those who are not afraid of success will go on to graduate school, especially in the scientific fields. The choice to go on in the less socially acceptable role is a two sided threat; the female is not only committing herself to a career but she may be relinquishing her chances of marrying: "the belief that a too strong commitment to career is, inter alia, inimical to a happy marriage..." (4:344).

In addition, our society is not very kind in its assessment of aggressive and/or single women. A passive woman is safe, whereas an aggressive woman is dangerous. According to Storr (16), she is a problem in our society and her aggressiveness may be due to her deeper sense of insecurity. He postulates that single people will take on the characteristics of the opposite sex:

> men living alone very often become fussy, old-maidish and soft; while solitary women exhibit a pseudo-masculine efficiency, a determined practical competence which they might expect or demand from a husband if only they had one. (16:73)

And, as if this were not enough, he proceeds to state that professional, assertive women are tiresome: "the women whose masculine aspect is not contained in the lover or husband becomes opinionated and dogmatic and shows that insecure assertiveness which men find tiresome when they work for female executives" (16:73).

The professional female physical educator has, by the mere fact that she has a graduate degree, somehow weathered the attitudes discussed so far. But the costs of career success still rise higher since there is an element of time involved. As stated in an earlier quote, sports require commitment: those who take teaching physical education seriously must

teach classes, conduct after school sports, attend conventions and workshops, and continue to further their education; those who are involved in research must teach, advise, and do more research. Consequently, Davis and Olesen conclude that:

> only a small minority — typically the older, unmarried, and childless — evidences serious career commitments, a circumstance which incidentally, helps account for the fact that it is they who are most commonly found in leadership positions in the women's profession. (4:341)

Apparently, the majority of females find the costs of career success incommensurate with the gains, and the number of men willing to understand the women who choose this road are few in number.

SUMMARY, IMPLICATIONS, AND CONCLUSIONS

It is the combination of all the factors discussed that accounts for the "Misses" strewn down the physical education roster in most college lobbies.

The woman who has gone to graduate school and is teaching physical education at the college level has not been afraid of success. The particular traits she possesses have compelled her to choose the "career way." While in college, she may have defied social pressures, peer pressures, and parental pressures in staying in her field — the problem is that somewhere along the way, she may have lost male social approval because she made her career an important part of her life. In a sense, she has gambled what she needs and wants against what is most accepted in our culture — to get married and settle down.

To do this in physical education is a double jeopardy. For the most part, sports are "masculine" oriented. The focus is on the men and the standards are set by the men, so that women interested in a "man's world" become mannish too. Part of the problem may be lack of knowledge on the part of the men about women's athletics so that hopefully the trend towards coed activities will bridge this knowledge and attitude gap.

The woman who succeeds in physical education has rejected the role of passivity, the role prescribed by many males for too many females. In choosing not to be mediocre, she has trampled on the toes of those people to whom she is a threat — particularly those men who desire a submissive female. If it is true that most men want a passive wife, then the very grain of her personality will not coincide with these men's needs. It takes a special type of man to handle an independent female without losing his own sense of independence in the process.

Then there is the time element. The nature of her job as well as the nature of her personality demands time away from home and flexibility of schedules. The chances are that she isn't wild about "domestic" chores, her job is demanding, and she has many interests. Working around this

type of pressure is difficult enough on herself, but especially difficult for a man to accept.

It should also be noted that unlike most other jobs where men and women spend a good part of their working day in the same vicinity, women physical educators tend to see nothing but more women from 9 to 5, 5 days a week, so that exposure to working with men is at a minimum.

However, the college physical educator is not totally a victim of circumstances. Possessing the particular traits she has, it is very easy to develop secondary traits of being too stubborn, too opinionated and too organized. The tendency to get into a rut or routine makes it particularly difficult for single people to develop outside meaningful relationships, especially if they use the above reasons as a rationale for never trying to meet a man.

It might appear that marriage is the end-all for all people and that female physical educators for the most part are doomed not to marry. Neither statement is true. For those women with the inclination and interest, it is possible to combine a career in a male-oriented field with marriage:

> the women are obviously feminine in appearance and both they and the men in class accept their professional commitment ... the problem of combining marriage and career is not seen by them as a conflict in aspects of the personality ... or as a threat to their femininity — just a problem in baby-sitters, cleaning help, and so on. (1:187)

It may simply be a case of being a little more difficult in physical education because of the "nature of the beast" as well as the "nature of the circumstances."

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CLINICAL AND STATISTICAL PREDICTION IN ATHLETICS

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One of the most difficult tasks of every coach is to evaluate the abilities and needs of her players, predict the players' future success and then to select those who will receive concentrated instruction and competitive experience. Today there are two major types of prediction methods available, clinical and statistical, to aid in selecting or indicating the future success of athletes. There are situations in which both simple clinical and statistical methods can be effectively used by a coach who is not a specialist in psychology or statistics.

Before one begins the task of selecting appropriate prediction procedures, it should be emphasized that the choice is not between clinical and statistical methods but rather in choosing the method or combination of methods which could most effectively answer the particular question posed. As Meehl says:

> There is no convincing reason to assume that explicitly formalized mathematical rules and the clinician's creativity are equally suited for any given kind of task, or that their comparative effectiveness is the same for different tasks. (10:vi)

PRESENT PREDICTIVE METHODS IN PHYSICAL EDUCATION

The coach uses demonstrated physical skills as one criterion for the prediction of her players' success in that sport. She also will watch each player use these skills in a competitive situation. In these situations she is relying upon her ability to see cues and her experience to predict which skills are most essential for success. After a number of practice sessions, the coach will decide which players to retain. This is a long and difficult decision which coaches often do not like to reach because they fear that they may not be completely correct in cutting certain players from the squad. What can be done to help the coach make these decisions accurately?

Lawther (8:170) states that the best predictive test of athletic ability is a sampling of performance in the activity. It has been the practice in physical education to isolate basic units of physical skills and test the athlete against some national or local norm. The common procedure

in constructing sport skill tests is to correlate individual scores on various skills with experts' ratings of those same individuals in that sport. Lawther states that:

> The assumption is that a high correlation of skill scores with judges' ratings establishes the validity of the test. Items which do not correlate significantly with expert ratings are deleted from the battery. (9:141)

In motor skill tests it is recommended that validity be above .85 and reliability be above .90. After a check of validities reported on 25 different sport skill tests, Lawther noted that only five of these had validity coefficients of .85 or higher (9:141). He also cites some computed probabilities of selecting from one to five of the best players from a squad of twenty-five by use of scores in a test battery correlating .80 with a completely valid and reliable criterion. "The estimate of the probability of being correct on four and wrong on one is .0776 and the probability for five correct is .0102" (9:139).

Lawther reports Morehouse as stating that individual selection of the most skillful players presents the following problems:

1. Ability to predict at extremes is dependent on the spread of the scores in the skill test. The more widely spread the scores are, the better are the chances of prediction.
2. Individuals vary in performance from day to day and even hour to hour.
3. The criterion with which the test is correlated is not a true criterion in itself because of errors in judgment of even the most expert raters.
4. The basic assumption of prediction is that the distributions of both skill-test scores and criteria are normal. This assumption could scarcely be made on the subjects in the typical athletic squad which reports for practice. (9:139)

Lawther notes our inability to find objective tests in team and dual sports and cites three major problems which seem to account for the difficulty in constructing skills tests with high enough validity to serve for individual selection or for prediction of later success.

1. Initial scores have little or no relationship to the amount or rate of improvement. Combinations of initial scores with cumulative learning scores (in a multiple "R") begin to have some predictive value about half-way through the learning, in simpler skills.
2. It is impossible to measure many of the factors which contribute to success in highly complex sports; e.g., personality factors, attitudes, adjustments to stress.
3. Specific items used, even if they are parts taken out of the activity itself, do not represent the same performance when isolated as they do when integrated into the larger patterns of whole activity performance. (9:141)

Lawther concludes that "we have not yet been able to find any means of evaluation of dual or team sport ability which even approaches the validity of expert judgment" (9:142). The judges must, however, meet the following basic conditions.

1. the one so judging must be really expert, not just some dubious "authority";
2. the expert must have first made careful observations of the individuals to be judged over an adequate span of time; and he must have been able to make comparisons of the respective individuals during performance;
3. the expert must have made (at least mentally) a rough outline of a case history of each individual to be judged, in the various behaviour situations and performances, competitive and otherwise. (9:142)

Physical prowess is only a part of the capabilities of an individual. Coaches are becoming increasingly aware of the mental or psychological capabilities of their players. In time, the coach knows the participants very well, for she has a wonderful opportunity to see them when they are happy, sad, working, playing, relaxing and under stress. Coaches will admit that it requires many months, even years, to know their players well but they feel confident to make decisions related to type of practice schedule, squad group , and their behavior toward the players, in what they consider to be a rational manner. Coaches are acting as psychologists since they are making clinical judgments. It would seem that research and techniques applicable to clinical psychologists should hold true for coaches.

Contrary to Lawther's opinion, it is possible to measure many factors such as personality, attitudes and adjustments to stress which contribute to success in sports. The following illustration of predicting success in athletics will be confined to a discussion of certain aspects of the assessment of personality.

Admittedly the determination of an individual's personality is a difficult endeavor since our tools are unsophisticated and the human organism so complex. However, the rewards for such knowledge will be great. For if we know an individual's personality, we have an indication of his behavioral pattern and can predict his responses. Personality may be assessed by interviews, observations, ratings, projective tasks and psychological inventories. The first three of these are particularly subjective assessments. The psychological inventories are of particular interest since they seem to hold the greatest potential for objective assessment. In the physical education research literature (12:301), inventories are the most frequently used technique for obtaining personality information. Inventories usually contain statements concerning personal feelings, attitudes and interests and measure various traits of personality. They are easy to score, permit group testing and do not require an exceptional amount of administrative time or clinical background on the part of the scorer (12:301).

It has been hypothesized that frequently it is the intangible something in personality that enables one individual to be more successful than another individual of equal training and skill. It may be the urge to win, the need to achieve or the willingness to suffer and forego pleasures during long training periods. Researchers are striving to measure the personality of the successful athlete to determine profiles or traits which may be common to most outstanding athletes. Ogilvie and Tutko (14) have used a rating scale based on the personality of superior male athletes to predict those professional football and baseball players who will be successful. This is the only extensive predictive work with athletes which has appeared in the literature.

Cratty states that:

> Certain combinations of personality traits have been shown to be predictive of superior performance in various athletic endeavors as well as in certain skills within the experimental laboratory.
>
> The writer has found that a group of personality traits which reflected freedom from agitation, high need for social approval, and lack of hostility to the environment was predictive of successful performance in complex tasks involving accurate movements of the total body. (3:20)

In contrast, Singer concludes that research shows that within a given sport the highly skilled male athlete has not been distinguishable from the lesser skilled athlete in personality (13:582). Using multiple discriminant analysis of the data, Singer found no significant differences in personality profiles between the tennis and baseball groups, or between the highest 20 and lowest 20 ranked baseball players. However, four variables, achievement, intraception, dominance and abasement, were significantly different at the .05 level, for the tennis and baseball groups. Only in the factor "order" were the low-rated tennis players significantly different from the high-rated tennis group. Between high and low-rated baseball players, no differences were found.

Very few studies have been conducted to assess the personality characteristics of outstanding women athletes. Ogilvie has concluded that outstanding women swimmers are very similar to the outstanding male athlete in traits contributing to success in athletics (11). He feels that there is a "female athlete personality". Jerome's review of literature lead her to conclude that "the degree of athletic ability relates directly and positively to personality difference" (5:51). The writer believes that too few cases and insufficient statistical analysis are available to come to such an emphatic conclusion in relation to intercollegiate and national championship teams. However, it is admitted that there seems to be a personality type for female competitors in team sports and a little different type for individual sport competitors. A recent survey of literature (1) showed that women on college or national teams had higher than average range personality factor scores on abstract thinking, autonomy, abasement and need for achievement than did their normative

populations. These teams frequently had lower than average range scores on affiliation, endurance, understanding and nurturance. The individual sport competitors were above the average range on abstract thinking and assertiveness and below the range on tough-mindedness as measured by the 16PF.

The obvious contradictions and uncertainty of conclusions drawn by persons who have recently conducted research into the personality assessment of athletes indicates that further research is needed. There is no reason, however, to feel that predictions should not be attempted. Personality profiles using the CPI, 16PF, EPPS and PRF might be given to athletes within one sport to identify a criterion group and to predict the success of later athletes. In this way a body of knowledge would be obtained so that eventually reliable predictions could be made. In addition, it is only through use and experimentation that these inventories may be refined or more accurate tools developed.

For the physical educator who wishes an overview, probably one of the best general coverages of the judgment abilities of humans to perceive motor skills and physical attributes is given by Knapp (7). She quotes several studies which indicate that neither teachers nor doctors are particularly accurate in their predictions. Knapp concludes that:

> In order then to make his observations as useful and accurate as is humanly possible a teacher should take every opportunity to check them and particularly against objective measures or tests. He should be constantly aware of the limitations of his observations and be continually alert against suggestion and prejudice. (7:39)

CLINICAL VS STATISTICAL PREDICTION IN PSYCHOLOGY

Standardized and objectively scored paper and pencil tests are used extensively in assessment of human traits, but both psychologists and physical educators view them with skepticism and often prefer to rely on their subjective judgment and professional skill for prediction purposes. Which of these contrasting methods yields the better assessment has been hotly debated within psychology. Kelly makes the following statement on the issues.

> One group takes the position that only by permitting the human assessor 1) to adapt the assessment situation to each subject, and 2) to serve both as a sensitive observer and as an interpreter of each subject's behavior can one hope to evaluate the really important aspects of a complex human personality and to predict future behavior. At the opposite extreme, another group argues that although human judges are still necessary in a wide variety of assessment situations and although the human mind is absolutely essential in the creation and development of new assessment techniques, nevertheless, the greater the involvement of human beings in the

assessment process itself, the less is the reliability and validity of the resulting assessments. (6:69)

Kelly (6:71) succinctly lists the types of procedures used in the two methods of assessment and prediction. He suggests that some combination of the two methods might prove to be better than either used alone. For example, highly objective test scores might be fed into a computer and the results be used as a basis for clinical inferences.

The coach may not yet feel the need for new theoretical and statistical concepts from psychology to increase her ability to coach since she feels that her predictions and decisions are already accurate and that they increase in accuracy as her experience increases. The same opinion exists among clinical psychologists so for the last 20 years researchers have been attempting to determine the accuracy of clinical judgments. According to Goldberg (4:484), the research has shown that clinical judgments are not accurate. A number of studies reported that the amount of professional training and experience of the judge did *not* relate to his judgmental accuracy. There are also studies which demonstrate that the amount of information available to the judge is *not* related to the accuracy of his resulting inferences. The judge's confidence ratings showed that the judges became convinced of their own increasing understanding of the case as the amount of their information increased. "Furthermore, their certainty about their decisions became entirely out of proportion to the actual correctness of those decisions" (4).

The reliability of the judgments is also in question. Studies have shown extremes from high consensus to low consensus for reliability across judges on the same data at the same occasion. For some tasks, however, there seem to be high correlations between judgments made by the same judge on the same data. Goldberg summarized this literature by pointing out that a rather simple actuarial formula can be constructed to perform at a level of validity no lower than that of the clinical expert.

Meehl (1954) postulated that:

> It is my personal hunch, ... , that a very considerable fraction of clinical time is being irrationally expended in the attempt to do, by dynamic formulations and staff conferences, selective and prognostic jobs that could be done more efficiently, in a small fraction of the clinical time, and by less skilled cultivation of complex (but still clerical) statistical methods. This would free the skilled clinician for therapy and research, for both of which skilled time is so sorely needed. (10:vii)

It would seem that there is a parallel situation between the clinician and clinical decisions and the coach and team selection.

SAMPLE PROBLEMS

To illustrate further the differences between the clinical and statistical methods of prediction, here are a typical problem and two methods for possible solution.

Problem: If we were to predict how an athlete was going to behave in a competitive situation, we might ask the following questions: How can we predict behavior so as to determine whether that behavior will lead to athletic success? Is present behavior indicative of success? Can we indicate what changes are necessary in order to achieve success? Can we predict the person's capacity for change? In what manner should we go about making these predictions?

Suggestion 1: Classify the subject as to skill level reached or as to some personality traits and enter an actuarial table which gives the statistical frequencies of behaviors of various sorts for persons belonging to the class. Actuarial tables compiled, for example, by life insurance companies are often used to obtain predictions on longevity because thousands of cases have contributed to those tables. In physical education we can predict physiological measurements and skill ability because sufficient statistical data are available. However, in studies related, for example, to the personality of women athletes far too little data are available to compile actuarial tables.

Suggestion 2: We might try the case study method of prediction. We conduct an interview, record background data, obtain test data and then formulate a hypothesis regarding the structure and dynamics of this particular individual.

Discussion: A decision process probably is followed by coaches but unfortunately all the information and the process is done in their heads. Perhaps the only written records the coach keeps are the times, distances or other concrete criteria of success. It is possible to record and compute clinical information and thus not have to make predictions based solely on physical characteristics of performance nor use some subjective mental process or guess work. The case of clinical study is called, by psychologists, a cognitive task. The problem is to decide which elements are most related to the prediction and what weight each of these elements should carry. There will be also instances of one element, when in the presence of another element, exerting an influence of a nature different from its usual response. In addition, the undesirable elements must be subtracted from the desirable elements. For example, a certain amount of aggression, independence and anxiety may be desirable characteristics in order to achieve athletic success; however, if the force of any trait became extreme or combined with suspicion, introversion or stubborness, it might be undesirable to have that individual on a team.

Chapman and Chapman concluded that some cognitive tasks often apparently exceed the capacity of the human intellect. "The ultimate solution, as suggested by Meehl (1960), may lie in at least a partial replacement of clinical psychodiagnostic methods by actuarial prediction" (2:204).

Researchers have attempted to express mathematically the extent of configural cue usage in the clinical judgment process. Goldberg (4:488) reported that studies have shown that the simple linear model appeared

to characterize quite adequately the judgmental processes involved. Further research did find that clinical judgments could involve the configural utilization of cues (4:491). However, Goldberg says, "the very power of the linear regression model to predict observations generated by a large class of nonlinear processes can serve to obscure our understanding of all but the most gross types of configural judgments" (4:491). He concluded that the best method of prediction was still the use of the simple linear model.

It is now obvious that there are times when the predictions made by a statistical approach do not agree with the predictions made by a clinician. If the statistical prediction, which is based on previous statistical experience, does not agree with the understanding of the problem as the clinician sees it, then it is necessary to decide whether practical decisions should be based strictly on statistical findings or modified by the insight of the individual clinician. This is the critical decision for the clinician or coach and it is at this point that the coach can make a unique contribution.

THE SPECIAL CONTRIBUTION OF THE CLINICIAN OR COACH

Meehl (10) discusses what the clinician can do with his facts beyond that which can be done by a regression equation. The clinician can in special cases give more weight to a factor than is given in the statistical procedure. He cites an example to illustrate the validity of this procedure. The problem is to predict whether a given professor will attend the movies on Friday night. A time-series study is made and a probability of .90 is given that he will attend next Friday. The clinician, however, knows that this professor recently broke his leg. This fact will change the probability to approximately zero.

The writer would suggest that all prediction scores and pertinent special information be considered before a decision as to predicted success or treatment is reached. A prediction of athletic success will be a combination of personality, physical skills and other factors, and therefore, the danger of important rare individualistic factors not being taken into account is minimized by a final review.

The second contribution of the clinician or coach will be to develop techniques for measuring hypothetical constructs and using them in testing hypotheses. Improvements are needed in the tools presently used in personality assessment, in addition to the development of methods to measure traits such as emotional maturity, social adjustment and individual responsibility (6:100). The tools should be made applicable to sport situations. The development of improved methods will serve to increase the boundaries of the unknown and, therefore, we will continue to need the skills of the theorist and practitioner.

GENERAL TREATMENT OF STATISTICAL DATA

Clinicians and coaches are under an obligation to show statistically that their predictions or assumptions tend to be correct. There are two

different ways of applying statistics to their problems (10:11). One is discriminative or validating use of statistics in which significance tests and predictions are made. The second is the structural or analytic use of statistics where factor analysis, covariance and correlational techniques are used.

> If we are interested in a straight prediction problem, ... factor analysis cannot ... improve upon straight regression procedures, where the sampling problem has been better worked out. If it is the intention to use results of the analysis for the improvement of testing instruments so that they will have greater inherent validity and 'purity,' ... use factor analysis. (10:13)

The distinction of the two ways of applying statistics lies in the aim of the procedure and the assumptions of a nonstatistical character which must be made in order for the aim to be reached.

There are two types of data, psychometric and nonpsychometric. This data in turn may be combined by two methods — mechanical and nonmechanical (judgmental, clinical, subjective, impressionistic). Meehl considers data to be psychometric if it meets the following four criteria: 1)standardized conditions of administration; 2) immediate recording of the behavior; 3) objective classification of the responses (scoring); 4) norms (10:15).

In the mechanical or statistical method, the prediction is arrived at by some straightforward application of an equation or table. Once the data has been gathered, the prediction determination could be turned over to a clerical worker or a computer. This saving of time for the coach or clinician is, in addition to objectivity, one of the assets of standardized tests and computer programs. A standardized personality test can be given to a group of athletes and machine or hand scored by a clerk immediately. The prediction model can be computer programmed. Therefore, if transportation of data were not a factor, the coach could have a prediction on each athlete in two days. This, in many instances, would be preferable to spending a month choosing a team. In most situations it requires a season for a coach to become well acquainted with her players, whereas with the assistance of objective personality data, the cues to behavior are available so that the coach may watch for the behavioral tendencies. If the coach and clinician are carrying out their essential and unique function of observing behavior during practices, games, and counselling, and in the locker room, they will be convinced of the predictive power of the statistical measurement. Previous to obtaining a profile, the coach may have only been able to see or feel certain characteristics of the individual because the comparative strengths of the personality factors were too complex for the human mind to compute. An example of the use of psychometric data, combined mechanically and used to develop a prediction model to assist in the selection, coaching and counselling of college women athletes is available in a recent dissertation (1).

THE UNAVOIDABILITY OF STATISTICS

The paraphrasing of Meehl's (10:16) summary of the use of clinical and statistical data provides an excellent summary to the foregoing discussion.

All coaches should make up their minds that the validating use of statistics is useful and inevitable. Regardless of one's theory of personality and regardless of one's choice of data, whether personality tests, age, marital status; regardless of how these data are fused for predictive purposes — by intuition, table, equation or rational hypotheses — the honest coach must ask himself whether he is doing better than he could do by flipping pennies. Coaches think they are using devices or methods of understanding individuals, but one cannot know until the method is validated. Coaches should want to record their predictions, allow them to accumulate and ultimately tally them up. Then the question of success must be decided. We need some objective criterion against which we can make objective predictions. Once these procedures are followed both clinical psychologists and athletic coaches will reap a harvest in terms of ability to assist other people.

Let us continue to discuss theories, techniques and problems with psychologists in order that the interdisciplinary study of psychology of sport may be developed and we can begin to assist in answering such questions as: 1) How can skills tests and personality tests be combined to make powerful prediction models? 2) How can a coach's anecdotal records be developed to objectively predict behavior in athletic situations? 3) How can the sport psychologist best report psychological information to the coach?

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SECTION 3

PHYSIOLOGICAL ASPECTS

CONDITIONING FOR STRESS IN SPORTS*

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Stress is a broad term with many connotations; it is usually associated with undesirable reactions and feelings. According to (Hans) Selye, stress in the medical sense is essentially the rate of wear and tear on the body. Subjective sensations of stress include: feelings of being tired, jittery, anxious, of having sore muscles from exertion, of being ill, of being out of breath from running. Stress causes certain changes in the structure and chemistry of the body. Some of these are signs of damage and others are manifestations of the body's adaptation reaction to stress.

Without a doubt, training and conditioning for sport performance and competition is stressful. Getting in shape, in essence, is adapting to the stresses that will be placed upon the body in sport. Some have used the SAID principle as a means of explaining what takes place. The SAID principle is a term coined to explain the concept of "specific adaptation to imposed demands." It refers to the extreme adaptability of the human body to the various kinds of stresses imposed upon it. Physical activity, i.e., muscular work, is a type of stress. In essence, coaching consists of training and conditioning for stress — both physical and psychological. However, the adaptation is very specific to the stress imposed.

Probably the muscular system demonstrates its adaptability to stress as much as any system. Strength demands have to be made upon the body to develop strength. There are many ways to do this in training and conditioning. However, regardless of the method of imposing stress, the muscle adapts by becoming stronger. While it is true that individuals with larger muscle mass have greater strength than those with less muscle mass, certain genetic and hormonal influences determine the extent of muscle bulk development. In girls, probably a bigger stress than muscular demands is the fear that they will become heavily muscled and look like a lady wrestler!

Strength demands, however, do not build muscle beyond the genetic and hormonal predisposition to do so. Hormonal secretions of estrogen,

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androgen, progesterone, and testosterone vary greatly among individuals, resulting in tremendous variances in muscular strength and development among members of one's own sex as well as between the sexes. It is probably safe to say that the difference in this strength factor among females is probably no greater than the difference between the male and the female. Girls whose physiques are more muscular, thus stronger per unit of weight, enjoy certain mechanical advantages over girls who rate low in muscularity; therefore, one sees a predominance of this type build among female athletes. Those girls with the 16-inch neck who put the shot were successful in that activity because of their genetic and hormonal predisposition. It is the inherent and morphological factors which produced this development, not vigorous physical stress. Putting the shot did not cause the 16-inch neck!

Other strength considerations concerning the female's response to stress demands should be acknowledged. The female generally starts at a lower level of strength and attains a lower maximal level through training. As an adult, her strength training response is approximately 50% of that of the male. In addition, the muscle definition observed in the male differs from that in the female because of the additional adipose tissue characteristic of her sex. This greater subcutaneous fat layer softens the muscular outlines. Thus, developing muscles to their maximal extent produces greater contour, muscle tone and curves which enhance the attractiveness of the female body rather than detract from it.

This tendency toward adiposity has some disadvantages as well as advantages in the sport performance of the female. The female has to carry her weight, muscle mass and fat, with her when she performs. Therefore, even though she may be as efficient as the male with regard to oxygen uptake in the working muscle, she still has to provide oxygen to her fat tissues as well. This tends to decrease her overall efficiency. Advantages include greater buoyancy in water because adipose tissue is lighter than muscle. The female has better insulation because of the fat layer; therefore she tolerates cold and heat better than the male. The female's skin temperature is higher in heat and lower in cold than that of the male. One concern here is that she possesses a slightly higher sweating threshold than the male; she does not begin to sweat until she is two or three degrees warmer than the male. The female also has fewer functional sweat glands than the male and these are arranged in patterns which differ from those of the male. The present implications are that the cost of maintaining heat balance in a hot environment is greater for the female and that this should be considered by all who deal with vigorous exercise in hot weather. This type of research has concentrated on heat stress of the male in sport; as more females begin strenuous training we need to explore this relationship for her as well. Some girls are now running up to 100 miles per week training for distance running; most of this training is taking place in warmer climates where temperature may be a factor. One thing that we do not know is whether efficiency in heat dissipation is sex-linked or developed by stress; the

question becomes: Can the female develop the same degree of efficiency through having these demands made upon her? As we get more females seriously training for athletics we may find that they develop cooling responses much like the male's. Heat stress becomes a real concern in activities like fencing, where the necessary equipment restricts the cooling process. It is also worth noting that the two most vigorous sports that females play, field hockey and lacrosse, also take place during seasons when extremely warm weather can be a factor. More attention needs to be paid to this concern before we lose a girl or two through heat exhaustion.

Cardiorespiratory endurance is another major adaptation to stress placed upon the body. Its development depends upon efficient respiratory, cardiac, and circulatory functions which result when these systems are stressed. Since the female is generally smaller than the male, she also has a smaller heart, thus less cardiac output. In addition, she has a smaller lung volume, therefore, a smaller vital capacity. However, the smaller organs do not prevent her from developing an efficiency comparable to that of the male. When evaluating maximal aerobic power on the basis of working muscle, the female can develop the ability to utilize approximately the same amount of oxygen per kilogram of body weight as the male.

Other factors related to this efficiency include the oxygen carrying capacity of the blood, or hemoglobin. Exercise stress produces changes in blood composition — the red blood cells increase in number for a short period of time with brief intensive exercise. The female has less hemoglobin than the male; this has been used as the explanation as to why she has a lower maximal oxygen uptake than he does. Since women lose some iron each month with the menstrual flow, and because research suggests that an anemia frequently results from sports training, it appears reasonable to find anemia among female athletes. In a study recently completed at Pennsylvania State University comparing hemoglobin concentration among females who were sedentary, moderately active, and trained, no evidence of iron deficiency anemia was observed as a pattern in any of the groups. However, significantly lower plasma iron concentrations and lower iron saturations in the younger trained and moderately active subjects were observed. Whether this represented a greater iron turnover and an increased rate of hemoglobin and myoglobin formation cannot be determined. Investigators have reported increased destruction of red blood cells with subsequent uptake of iron from the hemoglobin in early stages of training. This has been called athletic anemia in some discussions. Recent evidence indicates that female athletes may be low in iron. The prevalence of iron deficiency ranged from 22.5% for women athletes representing the Netherlands at the 1968 Olympics, 25% for the field hockey players participating at the National Tournament in 1971, and 32% for moderately active women in the State College, Pennsylvania, area to only 8% in a group of sedentary women in the same area. A 25% decrease in serum iron in women has been reported to occur following physical conditioning lasting from six

to eight weeks. Significant relationships have also been observed between the hemoglobin concentration and physical work capacity of women and the plasma iron concentration, hemoglobin concentration, and maximal oxygen consumption. The iron stores of the bone marrow have been found to decrease with increases in physical work capacity.

More research is needed in this area (particularly with high school and college women who participate in competitive sports) to determine the extent of iron deficiency in these groups. It would appear that there may be real need for insuring an adequate iron intake in the diets of females who participate regularly in strenuous physical activities. Perhaps an iron supplement is necessary for most females during this time.

The stress of endurance activities has also been a concern regarding the female athlete. It is interesting to note that females have been considered incapable of turning in creditable performances in endurance events. Only recently have they been allowed to compete in any distance beyond the 800-meter run. As indicated previously, some females are training up to 100 miles per week for running competition without any ill effects. They have been shown to have greater ventilatory capacity with maximal oxygen consumption approaching that found in the male long-distance runner. When one looks at the data available, the conclusion might well be that the female develops her peak physiological capacity around the ages of 12 to 14 and then it is "downhill" from that point. The cause-effect relationship is difficult to sort out with the data available. It appears as though this is a culturally induced peak. Now that the psychosociological barriers are being removed and more females are training and competing in endurance events, we may find that the female is much more like the male in terms of response to training over a period of time and that she is as capable of endurance competition as he is. Further, we may find that with regular training, she can continue to improve and her peak performance may be closer to the age that the male reaches his peak. We have not seen enough women concentrate on training for periods long enough to make this observation as yet. However, a number of females have recently competed with men in marathon races with a fair degree of success, finishing well up in the pack even though greatly outnumbered. The current observation is that the competitive age span is increasing. We see champion females as young as 12 and as old as grandmothers. More than half of the finalists in the 1952 Olympics were married and had children, many were over age 35, and at least two were grandmothers! In the last winter Olympics two of the gold medal winners were over 35 in the distance speed skating events and one was the mother of three children! In the past, most women retired from sports participation with marriage; today, they do not feel that marriage or parenthood sets any particular limitations. Further, women over 30 are not relegated to the rocking chair and content to "grow old gracefully." The beneficial effects of physical activity upon bodily processes far outweigh any other considerations in the long run and actually have a delaying effect upon the aging process.

In the study conducted at Pennsylvania State University on maximal

oxygen uptake in the female participating in varying levels of physical activity, females in their 60s who had continued to participate in moderate physical activity throughout their lifetime displayed greater cardiorespiratory efficiency than their sedentary counterparts who were 40 years younger! It was the physical activity that made the difference!

In summarizing the response of the female to physiological stresses imposed by training and conditioning and physical work it appears that the female may have a similar capacity in adapting to these stresses to the male's. It also appears that she has the ability to maintain her level of performance throughout her adult years in much the same manner as the male, provided she continues to participate in physical activity. There is no reason for her to be expected to peak physiologically during her teenage years and then continue downhill for the rest of her life. She needs vigorous exercise as much as the male and should be encouraged to get it on a regular basis.

So, without a doubt, training and conditioning for sport competition are stressful. Getting in shape, in essence, is adapting to the stresses being placed upon the body in sport performance. Adaptation takes time, thus training and conditioning take time. It becomes important to maintain this level of training and conditioning year round for best adaptation to the stresses of performance. Women, especially, have been guilty of not paying as much attention to this as they should. We have been so afraid that girls may take competition too seriously that we have specified a limited number of practices before one goes into competition. In general, these are too limited in number and are concentrated in too short a time to produce the adaptation necessary for the stresses imposed in sport performance. We need to impress upon female athletes the importance of year round training and conditioning for maintenance of a certain desirable level of adaptation. Training stipulations, competitive season length, and competitive performance restrictions should all be based on research and knowledge and not on opinion. More data and research are needed before we have a sound basis for establishing guidelines. Keep in mind that while the female responds to training and conditioning much like the male, the best of the female athletes will never be able to hold their own against the best of the male athletes because of the sex-linked differences in strength and speed factors. Because of this, it appears that the logical approach to competition is to have competition structured so that females compete with females and males compete with males, or to have mixed doubles compete against mixed doubles. As indicated previously, the variance of ability and potential for athletic performance is as great within the sex as it is between the sexes; there will always be some females who are superior to many males but there is no way that the best of the females can compete with the best males successfully. Because of the additional psychological and sociological problems during adolescence, this is certainly *not* the time to have males and females competing for the same positions on a team!

Psychologically, it appears that those females who have pursued excellence in sport through high level competition adapt to the psychological stresses as well. Admittedly, the female high level performers are a select and biased group; those who don't have what it takes drop out or never get involved in the first place! In spite of these findings, the female has to face a greater stress than the male in today's society because she is going against the expected, traditional feminine role when she commits herself to serious athletic competition. She faces a great dilemma; if she succeeds, she is not following the traditional feminine role; if she fails, she is not living up to her own expectations. Frequently, the best solution is to avoid the situation in the first place, or to drop out if things get too uncomfortable. We need to be aware of the gap that many female athletes experience between how they perceive themselves as athletes and how they perceive their expected role in society. Since the need for acceptance and approval from her peer group appears to be a culturally induced trait in the female in today's society, we must recognize that when she perceives this role conflict to the point of psychic discomfort, she will withdraw from athletics and sports competition unless she is helped to understand the dilemma she faces. This understanding may serve to prepare the female athlete for the stresses of competition more than any other psychological approach. Helping her to understand what she is experiencing will do more for her than 25 pep talks! We will continue to have this additional stress placed upon the female athlete until society endorses her athletic achievements as readily as those of her brothers.

Sport competition is one of many experiences which society offers an individual to add to one's life fulfillment, regardless of sex. The sport interaction situations are specific to sport and involve certain responses and behaviors in that situation. Sports actions and involvement are not necessarily masculine or feminine, the gender belongs to the doer, not to the sport or the thing being done!

Without a doubt, the healthy female can cope with the physiological and psychological stresses that sports competition demands. However, it will take greater understanding on the part of all of us to allow her to reach her full potential as an athlete.

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PROBLEMS OF TEMPERATURE REGULATION IN ATHLETICS

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The role of body temperature regulation in athletics has been ignored too long. Many problems of fatigue, lack of coordination and inability to continue performance result directly from excessive physiological strain because of the body's demand for adequate temperature regulation. Man is a homeotherm; that is, he is capable of maintaining his body temperatures within a very narrow range despite widely fluctuating environmental temperatures.

The responsibility for body temperature maintenance falls to the thermal regulatory mechanisms (TRM). The function of the TRM is to adjust our internal environment — our microbioclimate — to meet the demands imposed by our external environment (both indoors and outdoors). Understanding the human body's thermal regulatory mechanisms will make the problems of temperature regulation in athletics a relatively simple problem to understand and cope with.

THEORETICAL ASPECTS

The primary organ responsible for temperature regulation lies in the brain and is commonly referred to as the "body's thermostat," which is far too simple a concept to be entirely accurate. More specifically, it is called the *hypothalamus*, and is responsible for many internal adjustments in our bodies. A portion of the hypothalamus maintains our delicate thermal balance by regulating various effector mechanisms for the conservation or dissipation of internal heat. For example, if a drop of external temperature is experienced, "cool" signals from the skin are transmitted to the brain. The hypothalamus integrates all the signals it receives from both internally and externally located sensors (like a giant computer), attaches a meaning to these signals in terms of thermal regulation and transmits signals to the effector organs to cause blood vessel constriction to conserve heat and/or shivering to increase heat production. If a rise in external temperature is experienced, "warm" signals are received by the hypothalamus, and heat dissipating mechanisms are activated to increase the body's ability to dispose of extra heat via the mechanisms

of blood vessel dilatation and sweating. We have within us, then, a very complicated negative feedback system, a concept familiar to engineers and physiologists alike.

A general consideration of the basic avenues of physical heat exchange will enhance our understanding of what is happening within our bodies whenever we engage in prolonged physical effort or perform activities in other than a thermally neutral environment.

Conduction (K) involves the exchange of heat between two substances of different temperatures in direct contact with one another. Substances that readily transfer heat are conductors, while substances that do not readily transfer heat are insulators. Still air and body fat are good insulators. Water and muscle tissue are good heat conductors. This means that fat conducts less heat than does muscle tissue per unit time, and that cold water stresses a man more than does cold air. Furthermore, a lean man swimming in cold water will lose more body heat to the water than will a fat man.

Heat exchange via conduction occurs within the body as well. For example, conduction occurs between blood and muscle, between skin and fat, and between fat and muscle. It is important to realize that as body tissues become more perfused with blood, as occurs with exercise, conductivity (heat exchange) increases. Heat exchange via conduction is inversely related to the thickness of a surface or layer and directly related to the magnitude of the temperature gradient between the two contacting substances.

Convection (C) requires movement of one medium past another (convective currents) and is determined by the velocity, density and viscosity of the moving media, as well as the shape of the surface exposed to the convective currents. The quantity of heat exchanged is directly related to the effective surface area of one medium exposed to the other and to the temperature difference between the media. An example of convection experienced by everyone is that of windchill. In outdoor cold weather, wind velocity has a profound effect on those exposed. Anyone who has done any mountain climbing, downhill skiing, sailing or water skiing knows about windchill and the often decisive effect it has on human performance. Within the body too, convective heat exchange plays a major role, since the body tissues are bathed by venous and/or arterial blood which may be warm and/or cool according to the temperature gradient between the flowing blood and the tissue.

Radiation (R) involves the exchange of electromagnetic energy particles (photons) from one object to another (contact or convection currents are not required). Radiant heat exchange is directly related to the difference between the skin temperature and the radiant temperature of an object (not the air temperature), basic physical constants associated with radiation and the effective body surface area exposed to the radiant energy source. Since the human body is a 97% "ideal black body," it is very receptive to radiant heat exchange. The most obvious example of radiant heat exchange is heat gain from a hot summer sun or heat gain from a black asphalt playing surface. It is less obvious that we also

lose heat by radiation; for example, we lose heat to a clear blue sky while skiing. It may be important, therefore, to wear head protection if one is to perform for a long period of time under a bright summer sun as well as under a clear winter sky.

A major avenue for heat exchange in terms of athletic activity is the process of evaporation (E). Evaporation requires energy in the form of heat to change a liquid to a gas. This energy is termed the latent heat of vaporization. When water passes from a liquid state to a gaseous state, 0.58 kilocalories (kcal) are required per gram of water.

There are two forms of evaporative action of importance to man. One form involves our expired air which is nearly completely saturated with water vapor. Approximately 8 or 9 kcal are lost per hour at normal rates of breathing. With exercise, greatly increased rates of ventilation occur, yet the quantity of heat lost from the body in this manner is still relatively minimal. We are not efficient "panters."

Sweating, on the other hand, is a very important form of evaporative heat loss. If the ambient air is dry and moving, evaporation will occur readily and great quantities of heat will be lost from the body. If the ambient air is moist and/or stagnant, heat loss is limited. In the latter case, it is not the amount of sweating that determines heat loss, but the amount of evaporation.

The thermal balance of our body is regulated via various physiological mechanisms that enhance or depress heat exchange according to the following basic equation:

$$M = \pm R \pm C \pm B - E \pm S \pm W$$

M equals the total energy released by oxidative processes and is indirectly measured in the laboratory whenever we measure oxygen uptake; S represents body heat storage, i.e., temperature gain or loss; and W represents the mechanical heat of work either imparted to the objects we manipulate (for example, the quantity of heat lost to the braking mechanism while pedaling a bicycle), or gained by our muscles and joints.

This entire process is, of course, dynamic and continuous in nature. If body heat loss were prevented, a resting body in a neutral environment would generate enough metabolic heat to add approximately 1.8°F to the body temperature per hour. Light muscular activity causes the body to gain considerably more heat unless physiological mechanisms enhancing heat loss quickly respond. For homeothermic regulation to occur, the amount of heat gained (or lost) by the body must equal the amount of heat dissipated (or gained) by the body. Very simply, when H_{gain} equals $H_{dissipation}$, then T_{body} exhibits no change (there is no heat storage gain). When H_{gain} exceeds $H_{dissipation}$, then T_{body} increases (there is a positive storage gain), and when H_{gain} is less than $H_{dissipation}$, then T_{body} decreases (the s factor becomes negative).

APPLICATION TO ATHLETICS

For our purposes here, discussion of temperature regulation in athletics will be limited to heat stress, for the active athlete is not concerned

with cold stress except under rather extreme environmental conditions such as those represented by mountain climbing. Even in a mild climate an athlete faces heat stress — for heat stress is the result of additive factors, including the *internal heat load of exercise* and the *external heat load of the environment*. This latter factor is determined not only by the ambient (or dry bulb) temperature, but by the relative humidity, the radiant temperature, the athlete's body structure (fat or lean) and perhaps his state of hydration or dehydration.

Circulatory Control. Upon commencement of exercise, metabolism — oxygen uptake — increases rapidly, blood flow to the superficial areas of the body — particularly the skin — decreases, while flow to the active muscles increases in response to the extra demand of these muscles for oxygen. Gradually, as the body adjusts to the demands of exercise, the rapidly Increasing muscle temperatures heat the blood bathing them. If body temperatures are to remain within normal exercise body temperatures, effector mechanisms for heat dissipation must be activated. These mechanisms include increased circulation to the skin — enhancing heat loss via convection, conduction and even radiation — and generalized thermal sweating — for evaporative heat loss.

With heavy or prolonged exercise loads a situation of circulatory "compromise" develops. Not only must the cardiovascular system provide the energy sources demanded by the working muscles as a result of increased metabolic demands, but it also must provide increased cutaneous blood distribution to serve the increased demands for heat dissipation. Furthermore, the excess sweating that occurs with heavy exercise acts to dehydrate the blood.

The blood takes water from the tissues it perfuses to restore its water level. Because cellular dehydration is rather precisely regulated, the total quantity of sweat is controlled. The body can sweat approximately one quart per hour; but after several hours sweating decreases, and unless the internal heat load is drastically reduced, heat illness is imminent. An acceptable rate for prolonged sweating is estimated to he approximately 0.5 qt/hr. When this level is exceeded, sweating may decrease, particularly if fluid replacement is ignored. Curtailment of sweating is a danger signal that must not be ignored. Usually it is associated with dehydration, a rise in heat storage, i.e., a dangerously high body temperature, and a decreased cardiac output. These factors could well lead to circulatory collapse.

The circulatory system, then, is the "dynamo" of the thermal regulatory system. It determines the rate and direction of heat exchange via conduction and convection, and it transmits tissue fluid to the sweat glands to regulate sweating. If strenuous exercise, which imparts a heavy internal heat load, is coupled with a high environmental heat load (high ambient temperature or, more commonly, a moderate ambient temperature with a high relative humidity), a disproportionately large fraction of the athlete's "circulatory power" is diverted to temperature regulation. Performance capabilities will be severely impaired. Some obvious symptoms

may be muscular weakness, dizziness, blurring of vision, extreme fatigue, discomfort from high water loss, muscular cramps and collapse.

Glandular Control. The stimulus for hormonal control comes not from heat stress itself, but from changes occurring in water and electrolyte balance. Thirst sensations caused by water losses from sweating exhibit a characteristic time lag, so that an athlete seldom drinks enough water to retain his fluid volumes. As a result, an increase in osmotic pressure or a decrease in circulating blood volume may act to trigger secretion of ADH (antidiuretic hormone) from the pituitary gland. This hormone causes increased reabsorption of water in the kidney, thereby reducing urine output. This, of course, is an important protective reflex.

Because sweat is characteristically high in sodium and chloride concentration, high sweat loss leads to changing electrolyte balance in the fluid compartments and blood plasma. Aldosterone, a hormone from the adrenal cortex that acts to conserve sodium, is stimulated in some way by a change in electrolyte balance. However, potassium may be excreted in the place of sodium to such an extent that a serious potassium deficit may develop. At least one laboratory group has linked potassium deficit with heat illness.

The Core-Shell Concept. There is no single body temperature; there are many. What is commonly understood as body temperature is, physiologically speaking, deep body tissue or core temperature. Core temperatures must not be allowed to vary more than a few degrees because the central nervous system and basic functions would be endangered. The body's shell, i.e., the superficial layers of the body, deviates widely in temperature, depending primarily on environmental conditions. The shell includes the skin, subcutaneous adipose tissue and possibly the limb musculature and bony structures. Precise anatomical lines cannot be drawn between the core and the shell because their relative sizes covary with the thermoregulatory demands of the internal and external environments.

The core-shell concept is important to understand because heat exchange is dependent upon the proper maintenance of a temperature difference or gradient between the core and the shell. In the heat, for example, the shell must remain approximately 2°F below the core temperature, or the skin will act as an insulating barrier to heat dissipation to the exterior. Sweating, or more properly, evaporation of sweat, as well as serving as a means of body heat loss, keeps the skin surface cool. In the cold, on the other hand, the shell cools considerably, protecting the integrity of the deep body tissues by slowing down the heat exchange from the core to the exterior. If the shell were as warm as the core during cold exposure, the body would lose heat very rapidly.

Application to Clothing Needs. Uniforms and protective sport clothing ought to be designed and worn with the demands of thermal regulation in mind. At least three factors are important in planning sport clothing: 1) the circulation of air about the body to enhance or prevent convective, conductive and evaporative heat exchange; 2) the thermal resistant capabilities of the materials to enhance or prevent conductive and radia-

tive heat exchange; and 3) the reflective quality of the material to enhance or prevent radiative heat exchange.

Evaporative heat loss is experienced only if secreted sweat is exposed to air lower in water vapor pressure than the skin surface itself. This requires circulating air. Often clothing — particularly nylon or dacron coverings—prevents such air circulation close to skin surfaces. Sometimes it is desirable to protect a warm body from cold air, but more often in sport performance it is important to keep the skin surface cool, not cold, and as dry as possible, by natural evaporation. Wet clothing next to the skin serves no worthy purpose and may cause chilling in cold air or a serious gain in body heat when the internal heat is very high.

Materials differ in properties of thermal resistance, that is, they differ in their ability to transfer heat. If retaining body heat is desirable, then materials of high thermal resistance, e.g., wool, would best shield the body. If, on the other hand, it is desirable to allow body heat to escape, materials of low thermal resistance, e.g., cotton, are best.

The solar reflective quality of clothing is probably most influenced by color. It is not mere fancy that desert wear is light in color. It is well known that dark colors absorb a greater portion of solar heat than they reflect. Still, little attention has been paid this fact in the design and selection of sportswear.

Other factors to be considered in the selection of sport and athletic clothing include the ability of the cloth to dry, the flexibility (stiffness) of the material, the air permeability of the weave, and the moisture absorption capacity of the material. Begin analyzing clothing needs with a careful survey of environmental and physiological demands. What is it that the athlete needs most in clothing — attire that enhances heat dissipation or heat conservation?

Water and Salt Management in Athletics. Water comprises approximately 70% of the body's weight. It carries vital electrolytes such as sodium (Na^+), chloride (Cl^-), and potassium (K^+) to all parts of the body. A disturbance in water balance, as may be seen with prolonged and excessive sweating without water replacement, is seldom seen without a simultaneous change in the electrolyte balance of the body. Salt depletion heat cramps and dehydration heat exhaustion may result. If the substances lost are replaced, these drastic symptoms can be avoided.

The No-Water Myth. Many coaches still believe that drinking water, especially large quantities of cold water, should be avoided completely during hot weather and intensive physical activity. In reality, small quantities of water, cool or warm, should be sipped rather continuously to replenish fluid lost. During light to moderate activity, thirst is probably an adequate guide for water replacement. Under extreme conditions of either high external a /or high internal heat loads, however, sensations of thirst are not sufficient to retain proper water balance. Under such conditions, the athlete should enforce a drinking regimen every few minutes.

Salt Depletion. Even if only a minor salt (NaCl) deficit occurs, steps must be taken to correct the balance promptly. If too much salt is lost,

water moves into the cells from the extracellular compartment with a consequent increase in cellular size. Nausea, vomiting and diarrhea may follow with still greater losses of body salt.

The High-Salt Myth. The belief that if a little salt is good, a lot will be better is erroneous. Too much salt creates as many problems as too little salt, for too much salt intake (NaCl) with excessive sweating leaches the body of potassium. K^+ accompanies Na^+ and Cl^- through the sweat glands and kidneys. If the kidneys are signalled by ADH to retain water and by aldosterone to retain Na^+, they do so. Potassium, however, is not retained. K^+ deficit (hypokalemia) causes depression of neuromuscular activity, which is certainly deleterious to high levels of physical performance. Hence, there is often need for K^+ supplement, as well as NaCl supplement, in cases of expected extreme thermal stress. Probably the best way to replenish the salts lost from the body from excessive sweating is by additional salting of food. In extreme instances of heat stress, buffered salt tablets may be taken, although it is preferable to drink 0.9% saline water.

The athlete must observe precautions against overheating, especially during the early period of training when one's physiological mechanisms are not yet adjusted to the stresses of the climate or the activity. The most hazardous period of heat stress occurs in the preseason conditioning or training period of fall sports. Special care should prevail after weekends, for there is such a thing as accumulated dehydration. A relaxing weekend in the sun serves to put off the body's defenses so that Monday and Tuesday's practices are particularly stressful. Water and salt balance may be disturbed after weekend activity even though care was taken during the weekdays before the weekend to preserve water and salt balance.

Acclimatization to a new thermal environment takes approximately four or five days, and is retained for only a few days at peak efficiency unless exposure is continued on a regular basis. If peak performance is expected for a particular sports event, practice should be held for several days prior to the event in the climatic conditions expected. Hopefully, knowledge of the physiological demands of the body for adequate temperature maintenance and wise application of known facts regarding heat stress will alleviate heat accidents caused by strenuous or prolonged physical activity under unusual environmental conditions.

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IRON DEFICIENCY AND THE ACTIVE WOMAN

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For many years the public has been made aware of the symptoms and cure for "tired blood" by the makers of one of the leading iron tonics. More recently the advertisements for iron compounds have been directed toward the younger woman. This change in emphasis is probably the result of the reports of widespread iron deficiency among young women. Recently, several reports have appeared which suggest that iron deficiency may be quite common among women who participate regularly in sports. This, in turn, has raised some questions concerning the relationship of iron deficiency to performance in physical activities. One might ask 1) whether a lowering of the iron content of the body and especially that of hemoglobin iron content might have deleterious effects on performance, and 2) if physical activity may in some way be responsible for lowering the iron levels of the body.

THE ROLE OF IRON IN THE BODY

Iron plays an extremely important role in the oxygen carrying mechanisms of the body. In the adult with normal iron stores 65% to 70% of the iron is incorporated into hemoglobin. Approximately 5% can be found in the myoglobin of the muscle, 1% or less is located in the enzymes and cytochromes and the remaining 25 to 30% is located in the body's iron stores in the liver, spleen and bone marrow.

Each molecule of hemoglobin contains four atoms of iron to which four oxygen molecules are loosely attached during the passage through the lungs. The extent to which the hemoglobin becomes saturated with oxygen depends on the partial pressures of both oxygen and carbon dioxide, the pH and temperature of the blood. In all but the most unusual situations this results in the arterial blood being approximately 98% saturated with oxygen. However, the volume of oxygen carried by the blood is dependent on the hemoglobin concentration. A person with a hemoglobin concentration of 12 g per 100 ml of blood will only be able to carry 75% as much oxygen in his blood as a person with a hemoglobin concentration of 16 g per 100 ml, providing their red cell volumes are equal.

Iron is also incorporated into myoglobin and performs much the same role as with hemoglobin. It has been estimated that up to 500 ml of oxygen can be stored by the myoglobin of muscles (1). Since each myoglobin molecule contains one iron atom which can bind with one molecule of oxygen, the total amount of oxygen which can be stored is dependent upon the myoglobin content.

The ultimate use of oxygen by the cell involves the electron transport system of the mitochondria. Iron-containing cytochromes form an integral part of this system in which oxygen is converted to water with the production of ATP.

IRON NEEDS AND DEFICIENCY

Total iron stores of the body are dependent upon one's age, sex, body size and composition. Adult men have larger stores than either women or children. Daily turnover of iron in adult men and women who are not menstruating amounts to 1.0 mg. Menstruating women have a somewhat higher turnover dependent on the amount of blood lost with each period. The average blood loss amounts to 40 to 45 ml per period which is the equivalent of a 14 to 15 mg iron loss (12). This amounts to a 0.5 mg iron loss per day for a total loss of 1.5 mg per day. Women with heavier menstrual flows lose more iron and thus have a greater daily turnover. Pregnancy and lactation impose an additional iron requirement. An additional 2.5 mg of iron per day is needed during pregnancy to meet the needs of both mother and fetus (5). Lactation needs can be met by adding 0.5 to 1.0 mg per day to the normal 1.0 mg turnover. Growing children also have a greater need for iron. Girls need approximately 0.5 mg per day more iron during the periods of rapid growth than the 1.0 mg turnover replacement.

Only 5 to 10% of the iron in food is absorbed. The remainder passes through the digestive tract and appears in the feces. Once iron is absorbed into the blood stream it is bound to transferrin, the iron carrying protein, and delivered to the bone marrow for hemoglobin formation or is stored in the liver or spleen. The only avenues of iron loss once it enters the body are through epithelial cell desquamation, sweating, urine and the feces (a small loss) and through the loss of blood (see Figure 1).

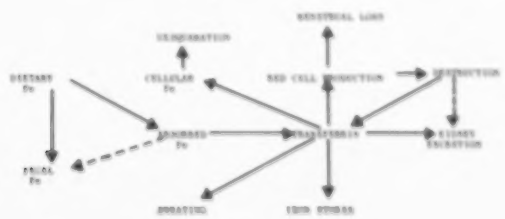

Figure 1 IRON METABOLISM
Adapted from Bullock and Jacobs (4)

The recommended dietary allowance for iron is 18 mg per day for menstruating, pregnant and lactating women (20). Dietary surveys of the iron intake of women estimate an average intake of 11 to 12 mg per day (25). If 10% of the intake is absorbed, this would mean only 1.1 to 1.2 mg per day would be absorbed, slightly less than the amount needed to balance iron losses and considerably less than the recommended allowance. This deficit must be made up from the iron stores which contain 200 to 400 mg (5).

Assuming that the iron stores are 400 mg and the average amount of iron absorbed is 1.1 mg per day, the deficit of 0.4 mg per day would lead to the depletion of the body's iron stores in 1,000 days, or approximately three years. As the iron depletion state develops there is an increased formation of transferrin in the liver and the total iron binding capacity of the blood increases. This is followed by an increased absorption of iron through the small intestine which may temporarily delay depletion of the iron stores. Eventually the level of iron carried in the plasma begins to fall. When the body can no longer meet the requirements for iron, the rate of hemoglobin formation begins to decrease and a smaller red blood cell containing less iron is formed (13). This final stage leads to a condition known as iron deficiency anemia which is characterized in the nonpregnant woman by a hemoglobin level below 12 g per 100 ml of blood.

Clinically the best method of detecting iron depletion is through examination of smears from the bone marrow. Iron deficient states can also be determined from blood samples when the plasma iron level is 50 g per 100 ml of plasma or less and less than 15% of the transferrin is saturated with iron (5).

RELATIONSHIP OF IRON AND HEMOGLOBIN TO PERFORMANCE

Sproule et al. (22) examined respiratory and cardiovascular functioning both at rest and during exercise in subjects who had less than 10 g hemoglobin per 100 ml blood. At rest the anemic subjects had significantly greater respiratory rates and larger ventilations, larger cardiac outputs and stroke volumes and a lower arterial-venous (a-v) oxygen difference than normal subjects. During strenuous exercise, running on the treadmill, cardiac output and stroke volume were the same in both the anemic and normal subjects; however, the amount of oxygen transported by the blood was severely reduced as was the rate of oxygen removed from the blood. The anemic subjects were able to utilize a significantly greater percentage of oxygen present in the blood during exercise than the normal subjects.

More recent work by Edgerton et al. (9) has suggested that when rats which have been kept on an iron deficient diet are exercised on the treadmill to exhaustion their capacity for work is directly related to the hemoglobin concentration. Compared to control animals the moderately and severely anemic rats had significantly lower capacities for running,

but when hemoglobin levels were restored through iron supplementation no differences among the groups were observed.

Anemic women exercising at submaximal levels for short periods of time have not been found to have differences in oxygen consumption or ventilation, but the anemic subjects did have higher heart rates (6). No significant improvements in performance during submaximal work have been observed following iron repletion in iron deficient subjects (2).

Ericsson (10) found that in older men and women (ages 57 to 71) the amount of iron stored in the bone marrow was related to changes in the physical work capacity. Supplementation of iron produced an increase in physical work capacity.

Significant increases in the maximal oxygen consumption of anemic women have been found following iron supplementation (11). The hemoglobin concentration was also found to be significantly related to the maximal oxygen consumption of these subjects. In a group of highly trained women field hockey players, none of whom were anemic, significant relationships were found between the plasma iron and hemoglobin concentrations and the maximal oxygen consumption (14).

It would appear that low hemoglobin levels may have an effect on strenuous exercise. On the other hand, submaximal work may be less affected since oxygen transport in the blood is not severely taxed.

EXERCISE AND THE DEVELOPMENT OF IRON DEFICIENCY

Lower hemoglobin levels have been reported in highly trained men athletes (23). DeWijn et al. (8) found that among athletes training for the 1968 Olympics, 9% of men and 22.5% of the women appeared to be iron deficient. Lower than normal plasma iron levels were observed in 25% of a group of women field hockey players and 32% of a group of moderately active women, while only 8% of a group of sedentary women were so classified (14).

An actual lowering of the hemoglobin level has been observed during the early phases of training (3, 7, 26). This so-called "sports anemia" is believed to be caused by an increased destruction of red blood cells. Animal experiments have shown that the iron from the destroyed cells is preferentially used in the formation of new red blood cells (27). An increased uptake of iron, presumably to form myoglobin, has been observed in the muscles at the same time. The myoglobin concentration in the muscle has been found to increase during training (18). Training has also produced an increase in the cytochrome content of the mitochondria (12). Edgerton et al. (9) found a significantly lower cytochrome content in the gastrocnemius muscles of anemic rats and a lower myoglobin content in the soleus than in control animals. However, the myoglobin level of the gastrocnemius was not significantly reduced in the anemic animals.

Exercise effects on the hemoglobin and iron levels have also been observed in humans. There are reports of increases in the total hemoglobin content of the blood following training (15, 17). Sumiyoshi (24) reported that women athletes were more likely to show low red blood cell counts during training than men. The greatest changes were found to occur three to six months after training began. A 25% decrease in the plasma iron levels in each of three groups of women was observed after a six- to eight-week conditioning program (16). In subjects not receiving iron supplementation Ericsson (10) found a decrease in the iron content of the bone marrow with increases in physical work capacity.

The greater susceptibility of women to iron deficiency and/or anemia during physical training is probably the result of their greater daily loss of iron through menstruation combined with a less than adequate dietary replacement. Men have a larger intake of dietary iron, although they do not necessarily absorb more, because of their larger caloric intake. They also have a smaller daily iron loss. It is quite possible that many girls and women will already have their iron stores somewhat depleted before the sports training season begins. Scott and Pritchard (21) found that nearly two-thirds of a group of college women had little or no iron stored in their bone marrow.

At the time the recommended daily allowance for iron was increased for menstruating women from 15 to 18 mg per day, it was proposed that in order for women to be able to meet this allowance an enrichment of at least 40 mg iron per pound be added to flour (19). The Food and Drug Administration has made such a proposal; however, it has been met with a great deal of opposition, especially from some physicians. Until such time as there is a nation-wide supplementation program, coaches should give serious consideration to seeing that their women athletes are receiving an adequate amount of iron in their diets.

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SECTION 4

BIOMECHANICAL ASPECTS

THE WOMAN ATHLETE: STRUCTURALLY SPEAKING

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The classification of the human physique into body types has aroused the interest of investigators for centuries. As early as 400 B.C. Hippocrates characterized the short and thick individual as the *habitus apoplecticus,* and the long, thin person as *habitus phthisicus.* About 219 B.C. Philostratos wrote "Concerning Gymnastics" in which he classified Olympic athletes according to type (lion-figured, eagle-like, splinter-shaped and bear-like).

Since the first criterion in developing scientific knowledge is the collection and classification of its components, it is not surprising that many pioneers in the field of physical education dedicated their efforts to this problem (1, 2, 8, 36). Champion German athletes were described by Schmidt and Kohlrausch, who stated that "The prominent representatives of the different sports have a definite build (physique) fitted or suited for their respective sport ..." (37).

Di Giovanna used structural items (weight, height, sitting height, shoulder breadth, chest depth, hip breadth, arm span and arm girth, as well as scores for arm-pulling force, arm-pushing force and total strength) to establish their relationship to success in college athletics. He concluded that, "different sports tend to favor individuals who are uniquely patterned structurally and functionally."

Specifically, baseball players were shorter, had greater arm girth, arm pull, total strength and power. Basketball men had greater explosive power, were taller, heavier, had greater sitting height, leg length, shoulder breadth, chest depth, arm span, and greater strength of legs and arm-pull. Gymnasts were shorter, had greater explosive power, shorter legs and narrower hips. They were also unique in having greater arm girths, stronger grips, higher arm strengths, and above-average scores on total force (13).

One of the first investigations in the area of women's athletics was made by Watson in 1937. She related distance in throwing to 19

anthropometric measures which she scaled on 477 college women. Her conclusion was that a low relationship exists between body measurements and the ability to throw (47). Contrary to these findings, Cureton stated in 1947 that successful throwers were heavier and stronger and possessed greater arm span than less able performers (10a). He also studied Olympic competitors in the 1932 and 1936 games and found few extreme endomorphs (fat) or ectomorphs (linear) participating in the games.* He concluded that muscular fitness and mesomorphy are fundamental to success in athletics. Endo-mesomorphs and ecto-mesomorphs are also patterned for outstanding performance. Following examinations of the participants in the 1948 Olympics, Cureton determined that the ecto-mesomorphic physique was the predominant build among the Olympic contenders (11a).

Sills and Everett investigated the relationship of extreme somatotypes to performance on motor and strength tests.

> The mesomorphs were superior on the strength tests ... endomorphs have a dead weight factor which is a handicap. On speed tests the mesomorphs were first, ectomorphs second, and endomorphs third; for endurance there was little difference between the mesomorphs and ectomorphs — again, the endomorphs were the poorest. (40)

Laubach and McConville (24) studied 63 college men to determine the relationships between flexibility, anthropometry and somatotypes. While the results indicated low and mostly insignificant correlations between the flexibility measures and the anthropometric measurements, fairly high significant correlations were reported between body fat and the flexibility measures. Flexibility, in other words, does appear to be reduced by increasing amounts of body fat. There were no significant correlations between the lever arms of the body and the flexibility measures, nor between lean body mass and the flexibility measures. In addition, there was a lack of relationship between the flexibility measures and the somatotype components. There were, however, generally high correlations between the anthropometric measurements and the somatotype components, as follows:

> Of the 189 coefficients that were computed, 78 of these were significant at or above the .01 level of confidence. Waist circumference, thigh circumference, arm circumference at axilla and MAL X skinfold all correlated at least .705 or above with endomorphy. Lean body mass (LBM) along with neck circumference, shoulder circumference and forearm circumference all correlated highly with mesomorphy. Stature yielded a correlation of .810 with ectomorphy while various other linear measurements correlated highly with ectomorphy. (24a)

Garrity (15) studied the relationship between the somatotypes of 202 college women and their physical fitness test scores. The subjects were somatotyped by the Sheldon method. Physical fitness performance was

*For definition of terms, see pp. 106-107.

assessed by the scores on the Kraus-Weber Test for Minimum Physical Fitness, the U.S. Women's Reserve Physical Fitness Test, and the Scott Physical Fitness Test. The findings indicated that successful physical fitness performances were related to the mesomorphic body build. The combination of strong endomorphic and ectomorphic components tended to limit performance. In addition, individuals with a mesomorphic-ectomorphic combination performed the tests more efficiently than individuals with the mesomorphic-endomorphic combination. The balanced group (444) tended to perform the tests somewhat more consistently and higher than most groups. Lastly, individuals strong in ectomorphy performed the physical fitness tests more efficiently than individuals with a strong endomorphic component.

In a study of 52 male physical education majors, Hebbelinck and Postma (19) determined the relationships between anthropometric measurements, somatotype ratings and certain motor fitness tests. The Sheldon method (38) was used to determine the somatotypes, and motor fitness was assessed by six tests. The anthropometric data (eight scores) indicated that the subjects showed a trend toward the athletic type as described by Kretschmer. A low or insignificant relationship was found between the body measures and the motor fitness tests with the exception of the .69 correlation between the shotput and neck girth. In addition, mesomorphy was the most distinctive body component of these physical education majors. Finally, the best motor fitness scores were obtained by the mesomorphic subjects with the ecto-mesomorphic types surpassing the endo-mesomorphic types in all the motor fitness tests except the shotput (19).

In an interesting study conducted at the University of Illinois, Perbix (32) compared the somatotypes of physical education majors (N=83) and women in the service curriculum (N=541). While endomorphy was the dominant component for the total group of college women, the physical education majors tended to be more mesomorphic than the in-service group.

In perhaps one of the most ambitious studies undertaken, Thorsen (43a) investigated the relationships among 43 measures of body structure and design as they affected the motor performance of 96 freshmen women. The performance scores were derived from a pure speed test, the Sargent Jump, the 600-yd run-walk, the back lift, the leg lift and the Strength Index. The results of the relationships between body structure and design and motor performance were reported according to the following breakdown: length measures, breadth and depth measures, trunk and leg areas, nonlinear expressions of body structure and design and an experimental combination of variables. Even though space does not permit a complete report of the findings, the following two results are reported with the intention of enticing a researcher to carefully scrutinize Thorsen's work before embarking upon a study in this area:

1. It appears evident that variables which express the size, length, and/or bulk of the trunk and legs are pertinent to the study of structure and physical performance in women.

2. The ratios of upper to lower leg, upper to lower trunk, and leg bulk to trunk bulk appear generally to be less significantly related to the selected performance tests when they stand alone as variables than when they are weighted by a second expression. (43b)

In response to a need to study motor performance in light of additional expressions of body build, Cress collaborated with Thorsen (9) to determine the relationship of masculinity and femininity ratings to the motor performance test scores of 147 college women. Eight motor performance test scores, Sheldon's somatotype ratings and androgyny ratings were obtained for each subject. The androgyny rating included both an andric (masculine presentation) rating and a gynic (feminine presentation) rating. Five androgyny variables were used in the data analysis, namely, an andric rating (A), a gynic rating (G), A/G ratio, A + G, and A − G. The results of the investigation indicated that androgyny is significantly related to selected tests of speed, strength, explosive power and motor ability of college women. More specifically, there was a significant positive relationship between masculinity and the motor performance tests of pure speed, the 50-yd dash, the Sargent Jump, arm strength and the Humiston Test. Femininity, on the other hand, showed a negative relationship to these identical motor tests. Further, the variable which expressed the preponderance of masculinity over femininity (A − G) was found to have the highest relationship to the motor performances of college women. Another finding indicated that androgyny ratings produced a higher relationship to motor performances of college women than the somatotype ratings. Even though previous investigations have reported significant correlations between motor performance test scores and somatotype ratings, Cress and Thorsen (9a) observed that "neither zero order nor multiple correlation coefficients have been of sufficient magnitude to enable accurate prediction of individual performance." The results of Cress and Thorsen's study suggested that androgyny ratings may be that expression of body build which will afford an accurate prediction of motor performance. There is an obvious need for additional studies in this area.

In a more recent investigation by Ross and Day (34) it was indicated that ecto-mesomorphic girls showed a slight advantage in a sample of skiers. In 1971 Brown and Wilmore (4) reported that women long distance runners were characterized as having slight, ectomorphic body builds, large lung volume, little body fat, a far greater than average ventilatory capacity, and their maximal oxygen consumption approached that found in champion male long distance runners.

Malina and his colleagues (25) examined the physique of female track and field athletes. They concluded that:

All athletes except the distance runners are taller than the non-athletic controls. Among athletes, the throwers are tallest, jumpers and sprinters intermediate, and distance runners the shortest. Body weight shows a similar progression. The throwers are heavier than the

> jumpers, runners, and controls, with little overlap. Within the throwers, the shotputters are heavier, while the discus throwers are taller ... The jumpers and throwers are longer legged. Relative to total length, distance runners and jumpers have the longest legs.
>
> In terms of body breadth dimensions, the throwers are larger in both shoulder and hip width. A similar gradient by event is apparent in the bicondylar breadths of the femur and humerus. Body build and body composition ... seem to set, to a large extent, the limits of an individual's track and field athletic ability.

Hirata (20), in discussing the physiques of Tokyo Olympic champions, emphasized that females showed the same structural tendencies as male competitors. He reported that distance runners are smaller and leaner; high jumpers are tall and lean; long and triple jumpers are lean and not so large. Throwers are large and stout. Divers are obviously small, while basketball players are extremely tall and rather lean. The physique of hockey players is almost the same as that of soccer players — small and a little stout.

Oyster and Wooten (29) investigated the influence of 18 selected anthropometric measures and ratios on the velocity attained by 107 untrained college women during the last 35 yards of a 50-yard run. They reported a correlation of –.72 between weight and the ponderal index, and .50 between velocity and the ponderal index. Weight and weight-related variables appeared to be exerting a slightly negative influence on the ability to run rapidly. The crural index (foreleg/upper leg) did not relate to velocity of the run.

In 1972, Sinning and Lindberg compared the physical measures of the Springfield College women's gymnastic team with data previously published on other samples of college women and European gymnasts. They stated that:

> Women gymnasts were smaller in skeletal diameters except for measures of the wrist, elbow, and femur. They were also smaller in circumference, except for measures of the upper arm, forearm, neck, and thorax. There were no significant differences from European gymnasts in height, weight, density or selected circumferences. It was concluded that the findings suggest a physique that may be characteristic of women gymnasts. (41a)

SOMATOTYPE METHODOLOGY

The study of human morphology in the United States was, to a great extent, derived from the research efforts of a number of European anthropologists; among these were Halle, Rostan, di Giovanni and Beneke (27a). In 1909 Viola (45) of the Italian school of anthropology differentiated three morphological types; he named these micro-splanchnic, normosplanchnic and macrosplanchnic. According to Page

(30) it was the brilliant writings of Kretschmer, a German psychiatrist, that stimulated interest in somatotyping in the United States. Kretschmer presented a four-fold typology: pyknic, asthenic, athletic and dysplastic. Unfortunately, he failed to integrate mixed types into his concept, and did not specify precise anthropometric criteria for each type.

Both of these criticisms were ingeniously answered by Sheldon, an American psychiatrist. Sheldon attempted to classify 400 male undergraduate students at the University of Chicago on the basis of Kretschmer's morphological typology. He discovered that 72% of the men appeared to be mixtures and that a large number showed conspicuous inconsistencies within different regions of their bodies. Accordingly, Sheldon concluded that an adequate classification of physique would have to be founded on four criteria:

> 1) The study of a much larger number of cases, 2) a method of attack which viewed the human physique as made up of an ad-mixture of components rather than as an example of a type, 3) a procedure for dividing the body into segments or regions for the purpose of comparative measurement and classification, and 4) a technique of comparison based upon permanent photographic records rather than upon isolated anthropometric measurements alone. (38)

It is interesting at this point to note that the photographic techniques utilized for the evaluation of posture by Dr. Frank Kleeborger (3) of the University of California were the forerunners of the somatotype photographic method. He devised a revolving pedestal which enabled him to photograph three views of his subject — anterior, posterior and lateral. Sheldon used this technique in standardizing his photographic method.

After photographing 4,000 undergraduate male students from several midwestern and eastern colleges and universities, Sheldon (38) found that he could identify three major components of body structure. These he designated as endomorphy, mesomorphy and ectomorphy — the names being based on the embryonic germinal layer from which each is derived.

> When endomorphy predominates, the digestive viscera are massive and highly developed, while the somatic structures are relatively weak and undeveloped. Endomorphs are of low specific gravity. They float high in the water.
>
> When mesomorphy predominates, the somatic structures (bone, muscle and connective tissue) are in the ascendancy. The mesomorphic physique is high in specific gravity and is hard, firm, upright, and relatively strong and tough. Blood vessels are large, especially the arteries. The skin is relatively thick, with large pores, and it is heavily reinforced with underlying connective tissue. The hallmark of mesomorphy is uprightness and sturdiness of structure, as the hallmark of endomorphy is softness and sphericity.

> Ectomorphy means fragility, linearity, flatness of the chest, and delicacy throughout the body. There is relatively slight development of both the visceral and somatic structures. The ectomorph has long, slender, poorly muscled extremities with delicate, pipestem bones, and he has, relative to his mass, the greatest surface area and hence the greatest sensory exposure to the outside world. He is thus in one sense overly exposed and naked to his world. His nervous system and sensory tissue have relatively poor protection. It might be said that the ectomorph is biologically 'extroverted' as the endomorph is biologically 'introverted.' (39)

Each of the three components was ranked numerically on a scale extending from 1 to 7 (this was later changed to a half-point scale). Thus, a 7 1 1 represented an extreme endomorph, a 1 7 1 an extreme mesomorph, and a 1 1 7 an extreme ectomorph; a 4 4 4 was considered a balanced physique. The sum of the ratings of the three components usually ranged from 9 to 12. Other parameters used were: height, maximal weight, and the ponderal index (properly this is the Reciprocal Ponderal Index), which is height divided by the cube root of the weight. Changes in this method of somatotyping have recently been described by Sheldon. He now employs a planimeter to measure the area of the thoracic and abdominal trunk areas. The upper trunk area is then divided by the lower trunk area to establish the trunk index. Tables are presently available for the assessment of both male and female somatotypes (35).

In evaluating Sheldon's contributions to the field of physical structure, Lindzey and Hall stated:

> It is clear that Sheldon's somatotyping procedure exists as an important contribution to the person who would study the human organism. It not only serves as an admirable link between the anatomical, potentially biological and the behavioral; it also provides a measuring technique for the individual who is solely interested in the structure of the human body. The human engineer, the physical anthropologist, and others who are not psychologists may derive from this technique unique assistance in their problems. (36)

Cureton's Method of Somatotyping

Cureton's (11a) approach to somatotyping is basically similar to Sheldon's in that he utilizes the somatotype picture; in addition, he measures several skinfolds and assesses muscular strength and vital capacity. He feels his system will place any subject at the location of the Sheldon-Stevens-Tucker triangle closely enough for all practical purposes. Carter and Heath (5a) report that Cureton's ratings on ectomorphy "average close to one unit higher than would be possible by using Sheldon's height-weight ratio tables." They seriously question the inclusion of performance scores for determining the somatotype, adding that such criteria are "arbitrary" and may lead to spurious relationships.

Parnell's Method of Somatotyping

In 1958, Parnell (31) described a "physical anthropometric method for quantifying the differences in body physique" which was intended to closely correspond with Sheldon's somatotype ratings. Parnell's components were named "fat," "muscularity" and "linearity." Parnell documented his variation on Sheldon's system of rating body physique by comparing, first, the scores of 154 males ranging in age from 16 to 20 years, and, second, the scores of 282 males. The results indicated that 90% of Parnell's scores were within a half point, plus or minus, of the Sheldon scores in the former group. In the latter group, 87.3% of the scores were similar (44a).

Parnell's system offers essentially a phenotype evaluation of the body's physique which can readily change as a function of nutrition or exercise.* In contrast, Sheldon claims his genotypic rating is stable throughout life, if properly determined (17). Parnell uses height and weight to calculate the ponderal index; in addition, three anthropometric measures are taken: 1) epicondylar breadths of the knees and elbows, 2) girths of biceps and calves and 3) skinfold thicknesses of the triceps, scapula and abdomen. These values are recorded on the Parnell M-4 Adult Deviation Chart, and the appropriate somatotype is then determined.

Haronian and Sugerman (18) in a study of 102 male university students found that Parnell's scores for muscularity averaged nearly a full point less than Sheldon's scores for mesomorphy. In a parallel study involving 71 female college students, Underwood (44b) reported a 1.04 lower fat score than Sheldon's endomorphy score. Underwood further remarked:

> Even though Parnell's method for body typing eliminated many of the impractical features of Sheldon's somatotyping, the findings of this investigation tended to cast doubt on the usefulness of Parnell's method for research and instructional purposes. The partial correlations indicated that body type components determined by Parnell's method were not independent factors, but that a rating in one component was related to factors involved in the rating of one of the other components... On the other hand, body types determined by Sheldon's newest method appear to be independent of one another. Correlations between similar components determined by the two methods also indicate that the two ratings are measuring factors which are different from one another. The two methods, therefore, should not be used interchangeably.

Heath and Carter's Method of Somatotyping

Heath and Carter have integrated various features of the Sheldon and Parnell methods with objectifications based on their own research. They define the somatotype as "present morphological conformation." The

*The phenotype is the evaluation of body structure at *that particular moment.*

following data are used in this method: age, height, weight, ponderal index, four skinfold measures (triceps, subscapular, suprailiac, calf), two bone diameters (humerus, femur) and two muscle girths (flexed arm, calf). They also utilize a revised height-weight ratio table. When the data are recorded on the Heath-Carter Somatotype Rating Form it is possible to determine the anthropometric somatotype directly (5b).

In addition to the methods described, other investigators have made valuable contributions to the field of body structure typing; among these are Damon (12), Dupertuis (14), Clarke (7), Hooton (21), Petersen (33), Willgoose (47) and Tanner (42).

BODY STRUCTURE AS A FACTOR IN ATHLETIC PERFORMANCE

Although considerable research has been devoted to the male athlete, there have been relatively few studies utilizing the female athlete. Morris' 1960 study (27) represents the most extensive study to date of female body structure in relation to athletic performance. For this reason, the next section will present Morris' major findings in the hope that they will stimulate and encourage other researchers.

The subjects included 150 outstanding women athletes and 164 women from the University of Illinois. They were screened for orthopedic handicaps and other health problems, and therefore were probably superior to the general female population. There was evidence (44) to indicate that the women athletes were generally superior to the unselected college women on tests of function and structure.

Differences Between the Athletes And College Women Samples

The athletes and college women were tested on the following items: 1) strength of right hand, 2) strength of left hand, 3) total hand strength, 4) back strength, 5) leg strength (without the belt), 6) total proportional strength, 7) strength/body weight, 8) back strength/leg strength, 9) leg strength/weight, 10) vital capacity (raw scores), 11) vital capacity (normed). These results are shown in Table 1, and the *t* values for the differences in the means are shown in Table 2. Nine of the 11 measures of function proved highly significant. Only vital capacity normed, and the ratio back strength/leg strength (5% level) were not significant at the 1% level of confidence.

The groups were further studied on the basis of structure; these measures included: 1) height, 2) weight, 3) Reciprocal Ponderal Index (height/cube root of weight), and 4) somatotype components — endomorphy, mesomorphy and ectomorphy. These results are tabulated in Table 3, and the *t* values in Table 4. Only weight and the Reciprocal Ponderal Index (RPI) were not significant. The athletes were clearly more mesomorphic, less ectomorphic, and slightly less endomorphic than the

Table 1
Inter-group Comparisons on Eleven Functional Measurements*

Item	Group	Mean	Median	Mode	S.D.	Range
Strength Right Hand	college	62.85	62.78	62.50	11.19	34 – 100
	athletic	80.45	80.57	82.50	12.52	60 – 122
Strength Left Hand	college	56.80	55.48	52.50	12.00	29 – 96
	athletic	73.67	73.09	72.50	12.16	40 – 112
Total	college	118.90	117.74	125.00	21.05	67 – 196
	athletic	153.07	150.83	145.00	23.13	100 – 232
Strength Back	college	216.22	213.76	210.00	40.92	100 – 310
	athletic	248.13	247.86	270.00	37.54	150 – 370
Strength Legs	college	223.90	215.84	220.00	63.88	80 – 400
	athletic	270.94	261.42	260.00	72.34	130 – 600
Total Strength	college	550.05	535.71	525.00	107.58	330 – 864
	athletic	663.40	660.48	655.00	111.27	406 –1,202
Strength/ Weight	college	4.35	4.25	4.13	.780	2.47– 6.80
	athletic	5.13	5.03	4.63	.999	3.12– 10.10
Back Str./ Leg Str.	college	1.02	.996	1.050	.257	.53– 2.13
	athletic	.96	.950	.950	.204	.51– 1.53
Leg Str./ Weight	college	1.75	1.74	1.88	.480	.69– 3.15
	athletic	2.07	1.96	1.88	.627	1.06– 5.04
Vital Capacity Raw Scores	college	202.30	200.00	195.00	27.07	140 – 298
	athletic	212.20	210.71	205.00	30.98	142 – 348
Vital Capacity Normed	college	–.634	–2.110	0.00	32.71	–103 – 90
	athletic	–6.400	–.640	–20.00	38.60	– 78 – 143

*Strength was measured in pounds; vital capacity in cubic inches.

Table 2
t Values for Differences of Means of Functional Measurements

Item	Group	M	d_M	*t* Ratio	Probability
Strength Right Hand	college	.876	1.348	13.06	very significant
	athletic	1.025			
Strength Left Hand	college	.940	1.369	12.32	very significant
	athletic	.996			
Total Hand Strength	college	1.649	2.508	13.60	very significant
	athletic	1.895			
Back Strength	college	3.205	4.442	7.18	very significant
	athletic	3.075			
Leg Strength	college	5.004	7.756	6.06	very significant
	athletic	5.926			
Total Strength	college	8.426	12.413	9.13	very significant
	athletic	9.115			
Strength/ Weight	college	.061	.102	7.64	very significant
	athletic	.082			
Back Strength/ Leg Strength	college	.020	.026	2.319	significant at 5% level, insignificant at 1% level
	athletic	.016			
Leg Strength/ Weight	college	.038	.054	5.076	very significant
	athletic	.051			
Vital Capacity Raw Scores	college	2.120	3.307	2.97	very significant
	athletic	2.538			
Vital Capacity Normed	college	2.562	4.070	.02	insignificant
	athletic	3.162			

$P_{.05} = 1.96; P_{.01} = 2.58$

college girls. It was noteworthy that a 44% of the athletes were rated 4.0 or higher on mesomorphy, but only 9% of the college women attained that rating.

The RPI for the athletes in this study was 12.83 which was remarkably similar to the value of 12.84 reported by Sheldon for 4,000 college women and close to the value of 12.90 revealed for the Illinois women.

For the 17 measures of structure and function, 12 proved highly significant, while two were significant at the 5% level of confidence. It is apparent, therefore, that the athletes differed from the control group on tests of function and structure, and hence could be considered a unique sample in the female population.

Differences Between the Athletic Groups

The subjects in the athletic group had participated in competitive sports for a minimum of four years. Included were All-American and All-Philadelphia hockey players, former Olympic and Amateur Athletic Union

national gymnastic champions, ranked tennis players, professional and national amateur golf champions, plus semiprofessional basketball players and outstanding members of the top college varsities in the Philadelphia area. The mean age of the athletes was 29 years, 6 months (the average age of the 1972 Olympic team was 25 years, 3 months).

In addition to the structural and functional data previously described, 18 photogrammetric measures were scaled from the somatotype pictures. These included segmental lengths, shoulder and hip widths, picture height (this correlated .97 with measured height), abdominal thickness and several bodily ratios. The coefficients of reliability for these variables ranged from .92 to .98; variance between the athletic groups was tested by means of the *F* ratio.

The number of subjects making up the 11 subsamples of the women athletes was as follows:

Basketball forwards	19
Divers	11
Golfers	12
Gymnasts	15
Hockey forwards	30
Hockey fullbacks/goalies	16
Hockey halfbacks	15
Softball	20
Swimmers	26
Tennis	14
Track	15

(Approximately 40 of the athletes appeared in two categories.)

Table 3
Inter-group Comparisons on Six Structural Measurements

Item	Group	Mean	Median	Mode	S.D.	Range
Endomorphy	college	4.96	5.27	5.00	1.20	1.5 – 7.0
	athletic	4.67	5.08	5.00	1.13	2.5 – 7.0
Mesomorphy	college	2.97	3.23	3.00	.74	1.5 – 5.0
	athletic	3.78	3.93	3.50	.88	2.0 – 5.5
Ectomorphy	college	3.19	3.32	3.00	1.02	1.0 – 7.0
	athletic	2.85	2.93	2.50	.89	1.5 – 5.5
Height	college	64.70	64.55	65.00	2.20	60.0 – 70.9
	athletic	66.09	64.95	65.50	2.44	60.0 – 73.5
Weight	college	127.62	125.65	125.00	17.00	92.0 – 193.0
	athletic	131.00	129.02	125.00	16.44	91.0 – 192.0
Reciprocal Ponderal Index	college	12.90	12.92	12.88	.519	11.31 – 14.67
	athletic	12.83	12.86	12.88	.485	11.31 – 13.97

Table 4
t Values for Differences of Means of Structural Measurements

Item	Group	M	d_M	*t* Ratio	Probability
Endomorphy	college athletic	.094 .092	.132	2.20	significant, 5% level insignificant, 1% level
Mesomorphy	college athletic	.058 .072	.092	8.77	very significant
Ectomorphy	college athletic	.079 .073	.108	3.16	very significant
Height	college athletic	.172 .199	.263	5.29	very significant
Weight	college athletic	1.331 1.347	1.894	1.78	insignificant
Reciprocal Ponderal Index	college athletic	.041 .040	.057	1.23	insignificant

$P_{.05} = 1.96; P_{.01} = 2.58$

RESULTS OF THE PHOTOGRAMMETRIC DATA

Obviously, within the scope of this article, it would be impossible to completely describe the results of the photogrammetric data; consequently, only the most significant relationships have been summarized. The term *Plus* as used in the chart below indicates that the athletic groups were at the top of the distribution, while *Minus* places them at the bottom (28).

Measures of Upper Extremity

Item	*Statistical Significance*	*Plus*	*Minus*	*Correlations**
1. Hand length	5%	B.B.; Hoc. f/g**	Div.; S-ball; Hoc.for.	.67 total arm length .45 foot length .63 pic. height
2. Forearm length	not signif.	B.B.;Swim.; Te.;Golf	S-ball; Track; Hoc.half	.73 total arm length .30 upper arm lg. .65 foreleg lg. .62 pic. height
3. Upper arm length	1%	B.B.;Swim.; Hoc. f/g	Hoc.half; Gym;Div.	.60 thigh length .66 total leg lg. .79 total arm lg. .85 pic. height

4. Total arm length	1%	B.B.;Hoc. f/g;Swim.	Hoc.half Hoc.for.; Div.	.82 total leg lg. .73 forearm lg. .79 upper arm lg. .55 pic. height
5. Shoulder width	not signif.	B.B.;Golf; Hoc. f/g	Hoc.half; Te.;Div.	.44 total arm lg. .57 weight .40 pic. height

Measures of Lower Extremity

1. Foot length	5%	B.B.;Golf	Div;Gym; S-ball	.56 foreleg lg. .54 total leg lg. .61 pic. height
2. Foreleg length	1%	Hoc. f/g; B.B.	Div; Hoc.for.; S-ball	.41 thigh lg. .82 total leg. lg. .75 total arm lg. .77 pic. height
3. Thigh length	1%	B.B.; Swim.	Div;Gym.; Hoc.for.	.86 total leg lg. .64 total arm lg. .65 pic. height
4. Total leg length	1%	B.B.; Hoc. f/g	Gym;Hoc. for; Div.	.42 mesomorphy .66 ectomorphy .82 total arm lg. .36 trunk length .84 pic. height
5. Hip width	1%	Golf; Hoc. f/g; S-ball	Gym;Div; Track	.41 shoulder width .76 weight .42 endomorphy

Trunk Measures

1. Trunk length	1%	B.B.; S-ball; Golf	Div.;Gym; Track	.49 ectomorphy .36 total leg lg. .63 pic. height
2. Abdominal thickness	1%	Golf;B.B.; Hoc. f/g	Track; Div;Gym.	−.35 trunk length .34 total leg lg. −.41 leg lg./trunk length

Bodily Ratios

1. Crural index	insignif.	Hoc. f/g; Gym;Div.	Te.;S-ball; Swim.	low correlations
2. Upper arm lg/ Forearm length	5%	S-ball; Track; Hoc. half	Golf; Te., Div.	.50 upper arm lg. −.68 forearm lg.

3.	Leg length/ Trunk length	5%	Track; Gym.; B.B.	Hec.for; Hoc.half; S-ball	−.54 hip width .29 shoulder wd. −.41 abdom. thick. .42 ht./ab. th. −.33 endomorphy .26 RPI
4.	Shoulder width/ Hip width	1%	Gym;Track; Div.	Hoc. f/g; S-ball; Golf	.27 thigh lg. .61 hip width .26 shoulder wd. .61 weight −.56 RPI
5.	Picture ht./ Abdominal thickness	5%	Gym;Div.; Track	Hoc. f/g; B.B.; Golf	−.63 hip width −.89 shoulder wd/ hip width .72 RPI

*The 1% level of confidence was .25.
**Hoc. f/g = hockey fullbacks and goalies.

Comments on Photogrammetric Data

It is apparent that each sport group included in the athletic sample displayed certain characteristics of structure that distinguished its members from the other subsamples. Many of these discrepancies in body build require additional investigation involving a much larger sample of women athletes. It is highly probable that the key to differences in athletic performance may be found in these unique attributes of physique.

It is of interest that the track women and hockey halfbacks had small feet but large hands; conversely, the golfers, tennis players and hockey forwards had larger feet and smaller hands. On the segmental length of the forearm, the hockey fullbacks and goalies ranked fifth, yet they were first on the foreleg measure. Divers had the shortest forelegs of all the athletes tested, but they were close to the mean on forearm length. Tennis players were characterized by long forearms and short upper arms. The gymnasts had longer arms and legs than did the divers. In addition, the gymnasts were broader in the shoulders.

Tennis and softball players were broad hipped, but narrow in the shoulder dimension. Basketball players had the broadest shoulders in the entire sample, but placed fourth on the hip measure. On trunk length, the hockey fullbacks and goalies ranked sixth, yet they were second in height. The reverse was true for the softball players; they were second on trunk length but sixth in height.

The crural index,* contrary to results reported by Cureton (10b) and Thorsen (43c), did not significantly differentiate the women athletes. Nonetheless, for the groups with a high crural index (hockey fullbacks/

*The crural index is found by dividing the foreleg length by the thigh length.

goalies, gymnasts and divers, it is highly possible that the index does relate to their performance. Obviously the crural index needs further investigation, as does the ratio of the upper arm to the forearm, which proved to be significant at the 5% level.

The ratio of the leg length to the trunk length (5% level) placed the track participants and the gymnasts at the top of the distribution. Cureton (11b) found that this ratio distinguished the agility and jumping types of athletes. To a degree this held true for the women. The shoulder width/hip width ratio was highly significant (1%) and clearly separated the gymnasts (high ratio) from the golfers (low ratio). It is noteworthy that all the groups who scored low on this ratio were involved in activities in which hitting for distance was an important element — i.e., golfers, softball players and hockey fullbacks/goalies.

Cureton (11b) first utilized the ratio of picture height divided by abdominal thickness which he found differentiated the linear from the ponderal type of athletic physique. For the women's sample, the ratio was significant at the 5% level; however, it correlated −.63 with hip width, and −.89 with the shoulder width/hip width ratios. These relationships are shown in Tables 5 and 6. This ratio also correlated .72 with the Reciprocal Ponderal Index (RPI), indicating that it might be of value in future studies of body structure.

Table 5
Comparison of Rankings on Endormorphy, Picture Height/ Abdominal Thickness, Shoulder Width/Hip Width, and Weight*

Athletic Group	Rankings on Endomorphy	Rankings on Pic. Ht./ Ab. Thickness	Rankings on Sh.Wd./Hip Wd.	Rankings on Weight
Gymnasts	1	1	1	1
Track	2	3	2	2
Divers	3	2	3	3
Swimmers	4	4	4	7
Hockey halfbacks	5	5	5	4
Tennis	6	7	8	5
Hockey forwards	7	8	6	6
Basketball	8	6	7	9
Softball	9	9	10	8
Golf	10	11	11	10
Hockey full-backs/goalies	11	10	9	11

*These rankings are arranged in order from least ponderous to ponderous.

Table 6
Comparison of Mean Rankings on Eleven Measures of Structure

Athletic Groups	Leg Length	Arm Length	Trunk Length	Picture Height	Sh. Width	Hip Width	Abdominal Thickness	Arm Ratio	Legs/ Trunk	Sh./ Hips	Pic. Ht./ Ab. Thickness
Basketball forwards	1	1	1	1	1	4	3	7	7	6	6
Hockey fullbacks/ goalies	2	2	6	2	3	2	2	6	3	9	10
Golfers	5	5	3	5	2	1	1	9	6	11	11
Swimmers	3	3	5	3	4	6	8	4	4	4	4
Tennis	4	4	7	4	10	5	5	10	5	8	7
Hockey forwards	10	10	8	9	8	7	6	5	9	7	8
Hockey halfbacks	8	9	4	7	9	8	7	3	10	5	5
Track	7	7	11	8	5	9	9	2	1	2	3
Softball	6	6	2	6	7	3	4	1	11	10	9
Gymnasts	9	8	10	10	6	11	11	8	2	1	1
Divers	11	11	9	11	11	10	10	11	8	3	2

Other physical characteristics produced results that were of statistical significance; these included measured height, weight, Reciprocal Ponderal Index, endomorphy and mesomorphy.

Item	*Statistical Significance*	*Plus*	*Minus*	*Correlations**
1. Measured height	1%	B.B.;Hoc. f/g;Swim.	Div; Gym; Track	.83 total leg lg. .84 total arm lg. .63 trunk lg. .97 pic. ht. .25 hip width .38 sh. width
2. Weight	1%	Hoc. f/g; B.B.;Golf	Div; Track; Gym	.46 total leg lg. .51 total arm lg. .52 height .76 hip width .57 sh. width .61 sh. wd./hip wd. –.51 ht./ab. th.
3. Reciprocal Ponderal Index (RPI)	5%	Te.; B.B.; Hoc. half.	Div; Golf; Hoc. for.	.35 total leg lg. .31 total arm lg. –.54 hip width –.56 sh. wd./ hip wd. .72 ht/ab. th. .46 height –.52 weight
4. Endomorphy	1%	Hoc. f/g; Golf; S-ball	Div; Track; Gym.	.42 hip width –.33 trunk lg./ lower limb lg. –.38 ht./ab. th. .32 weight –.34 RPI
5. Mesomorphy	1%	Gym.; Div.; Track	S-ball; Te; B.B.	–.42 total leg lg. –.28 total arm lg. –.36 height –.44 RPI
6. Ectomorphy	not signif.	Swim.; Te.; B.B.	S-ball; Hoc. for; Div.	.66 total leg lg. .62 total arm lg. .67 height .65 RPI .34 ht./ab. th.

*The 1% level of confidence for the correlations was .25.

Comments on Structural Measures And Comparisons with Related Studies

Height again proved to be a discriminating factor among the various athletic groups. The basketball players were the tallest and possessed the longest limbs, trunks and shoulder width of all the athletes tested. These facts were supported by the investigations of Di Giovanna (13), Hirata (20) and Horniak (22). The latter carried out an anthropometric investigation of 95 women competitors in the World Championship of 1968.

The gymnasts were small in stature; this finding was substantiated by data from Carter and his colleagues (6). They compared successful participants in the 1968 AAU Senior National Gymnastics Championships (male) with less successful competitors. The highly successful were smaller than the less successful. Cureton (11c) described the Danish gymnasts as short in comparison to other male athletes. Medved, in a study of 596 adult sportswomen from Yugoslavia, found that the gymnasts "...were smaller than average" (26). Sinning and Lindberg measured women on the Springfield College gymnastic team and concluded that they were of smaller stature (41). Hirata, in "Physique and Age of Tokyo Olympic Champions," stated: "it is an obvious fact that gymnasts are small" (20).

Weight was also a useful item in distinguishing the athletic subsamples. The hockey fullbacks/goalies were the heaviest, closely followed by the basketball players. Gymnasts were the lightest — this finding was supported by the study of Sinning and Lindberg (41). The correlation of .76 between weight and hip width was of particular interest.

With respect to the variables of height and weight, Knuttgen (23) made the following comments:

> The performance of various physical tasks can be either positively or negatively affected by a person's size and proportions; in certain cases size exerts no influence at all. In sports and in work such factors as height, reach, grip size, and weight could act to either help or hinder, depending on the task. The fact that various physiological capacities show strong relationships to physical size constitutes another reason for identifying it as an important category.

The Reciprocal Ponderal Index (RPI) was significant at the 5% level, thus substantiating its extensive use by many researchers in the area of body structure. The linear builds (high ratios) were found among the tennis, basketball and hockey halfback groups. Divers, golfers and hockey forwards proved to be the ponderal athletes (low ratios). The RPI correlated .72 with height divided by abdominal thickness, but the two distributions were *not* identical. As previously noted, a correlation of .50 between RPI and velocity of the run was too low for predictive purposes (29).

The ratings on endomorphy between the athletic groups were significant at the 1% level. The athletes who ranked high on this component were low on the shoulder width to hip width ratio, while athletes with low endomorphy scores had a high ratio. This finding was supported by Cureton's study of the Danish gymnasts (11d). He found a shoulder width/hip width ratio of 1.37 — the highest of all athletes tested. The women gymnasts in Morris' study (27b) likewise had the top ratio of 1.32. In the selection of gymnasts the coach or instructor should not ignore the important relationship between shoulder and hip widths. Athletic groups that ranked low on endomorphy (divers, track women, and gymnasts) tended to be high on the mesomorphic rating. The endomorphy score consistently correlated in the negative direction with length of limbs, height and the RPI, while these same variables were positively related to ectomorphy.

There was no significant difference between the athletic groups on the ectomorphic component — possibly because it is more characteristic of the male physique. The ectomorphic scores correlated with limb lengths and stature. They showed a .65 correlation with the RPI, but only .34 with the ratio of height divided by abdominal thickness. It is again logical to suggest that both of these ratios be included in future studies of physical structure.

In the range of somatotypes for the athletic series, 63% of the subjects were assigned ratings of 5 4 2, 5 3 3, 5 3 2, 4 3 3 and the balanced somatotypes of 4 4 3, 4 3 4 and 3 3 3. The modal somatotypes were the 5 4 2 and the 5 3 3. Several of the athletic subsamples were predominantly mesomorphic endomorphs, or endomorphic mesomorphs.

	Somatotype Ratings	*Groups*	*Percent*
1.	Mesomorphic endomorphs		
	5 4 2	Softball players	55
		Hockey players	43
		Golfers	42
	5 3 3	Basketball players	34
		Gymnasts	33
	5 3 2	Tennis players	29
		Divers	27
2.	Endomorphic mesomorphs		
	4 5 2	Gymnasts	33
	3 5 2	Tennis players	29
	4 5 3	Divers	27
	3 5 3		

Thus the mesomorphic endomorph was the predominant body physique of the female athletes in contrast to the ectomorphic mesomorph body build for the male athletes. A comparison of the intercorrelations between the three somatotype variables for two independent

samples indicated that the somatotype components assessed were three distinctly different aspects of physical structure.

Somatotype Components	*Inter-correlations** (N=150)	*Inter-correlations*** (N=71)
Endomorphy vs. Mesomorphy	−.26	−.15
Endomorphy vs. Ectomorphy	−.34	−.34
Mesomorphy vs. Ectomorphy	−.55	−.26

*Intercorrelations from Morris' athletic sample.
**Intercorrelations from Underwood's sample of Temple University women.

In concluding the discussion of body structure, the writers feel it is important to refer to the work of Tanner, who studied 137 male track and field athletes who competed in the 1960 Olympic Games in Rome. The measures collected for each subject included arm length, waist depth and waist width, as measured on the somatotype photographs, 14 anthropometric measurements, and X-rays of the upper arm, calf and thigh. The results of this investigation were extensive; the following results, therefore, represent only a few.

Results: Somatotypes

The athlete's somatotype is very different from that of the general population; half of the somatotypes present in the population are not represented at all amongst the athletes.

There are marked differences in somatotype distribution between competitors in different events. The discus, javelin, shot and hammer throwers mostly have somatotypes around 3 6 2 or 3½ 6 2. The track athletes and the jumpers, on the other hand, have somatotypes mostly ranging between 2 5 3 and 2 3 5 ... There are ten high jumpers ranging from 2 6 2 to 2 3 6; the most successful jumpers, however, all rated 4 or more in mesomorphy.

There is no indication that winning is associated with position in the somatotype distribution for the event, unless it be away from, rather than near, the mean.

Results: Body Measurements

There are significant differences in some body measurements between whites and blacks competing in the same event. Blacks have longer arms and legs, narrower hips and smaller calf muscles. They also have wider tibias, giving a different tissue composition to the calf.

The 400-meter men are large, long-legged, broad shouldered in relation to their hips, and fairly heavily muscled.

Long distance runners are small, short legged, narrow shouldered and relatively lacking in muscle.

Sprinters are relatively short and very muscular men as compared to middle distance runners.

The 110m hurdlers are large, long-legged sprinters; the high jumpers are tall men. They have the longest legs relative to the trunk of all the athletes.

The throwers of discus, shot, javelin and hammer differ greatly in physique from the other athletes. As a group they are taller and heavier, with larger muscles in relation to their limb bones, and longer arms in relation to their legs. (42)

Differences Between Athletic Groups On Tests of Function

In addition to the structural items, the women athletes were also tested on strength and vital capacity. The results were as follows:

Item	*Statistical Significance*	*Plus*	*Minus*	*Correlations**
1. Strength right hand	not signif.	Golf; Track; Divers	Hoc. for; Te.; Hoc. halfs	.25 total arm lg. .67 total strength .50 str./weight .34 vital capacity .27 height
2. Strength left hand	not signif.	Golf; Track; B.B.	S-ball; Te.; Hoc. halfs	.55 total strength .32 str./weight .32 weight .68 right hand str. .24 total arm lg. .25 picture ht.
3. Total hand strength	not signif.	Golf; Track; Divers	S-ball; Te.; Hoc. halfs	.67 total strength .44 str./weight .31 vital cap. .28 height .28 weight .27 total arm lg.
4. Back strength	not signif.	Track; Div.; Gym.	B.B.; Te.; Hoc. halfs	.60 total hd. str. .83 total strength .58 str./wt. .48 vital cap. .24 weight .58 rt. hand str. .52 left hand str.

5. Leg strength	5%	Div.; Gym.; Track	B.B.; Hoc. halfs; Swim.	.43 total hd. str. .59 back str. .92 total str. .29 vital cap. .33 mesomorphy
6. Total strength	5%	Div.; Gym.; Track	B.B.; Te.; Hoc. halfs	–.51 back str./ leg strength .41 vital cap. .32 mesomorphy
7. Strength/ Weight	1%	Gym.; Div.; Track	Swim.; Golf; B.B.	–.43 weight .24 RPI .83 leg strength .81 total str.
8. Back strength/ Leg strength	not signif.	Swim.; B.B.; Hoc. for.	Track; Gym.; Div.	–.55 str./wt. –.24 endomorphy –.26 mesomorphy –.77 leg strength
9. Leg strength	1%	Div.; Gym.; Track	Swim.; Golf; B.B.	no correlations available
10. Vital capacity (raw scores)	5%	Hoc. f/g; B.B.; S-ball	Golf; Track; Hoc. halfs	.48 back strength .41 total strength .29 height .34 weight .26 total arm lg. .38 shoulder wd.

*Correlations of .25 were significant at the 1% level of confidence.

Comments on Functional Measures

Golfers, as might be expected, scored the highest on hand strength. The difference between their right and left grips was less than for all the other athletes. Rather consistently, the divers, gymnasts and track women ranked higher on the strength battery. When leg strength was related to body weight, the ratio proved to be highly significant at the 1% level. Golfers who ranked 6th on leg strength moved down to 11th on the strength of leg/weight ratio while the tennis players changed from 11th position to 4th. This ratio appears to be an important variable in events involving running, agility or jumping. There was also a marked similarity in the placement of the athletic groups between leg strength/weight and total strength/weight.

Vital capacity scores related to height and weight with correlations of .29 and .34, respectively. Although one would expect track participants and hockey halfbacks to perform well on this measure, they were at the bottom of the distribution. Strength also was associated with vital capacity (r=.41). Of the 10 tests of function, 5 were insignificant, 3 reached the 5% level of confidence, and 2 the 1% level. The most important

finding was that gross strength alone was not the primary factor, but rather how it related to body weight. The relationship of leg strength to body weight was another important item in distinguishing the various athletic groups.

PRACTICAL APPLICATION OF BODY STRUCTURE MEASURES

The average physical educator will undoubtedly find that the somatotype methods, as described, are too time consuming to be of practical value to her program. Special equipment and additional funds to purchase and process film are needed. A more efficacious approach, therefore, would be to classify students subjectively by inspection. This process is termed *somatoscopy*. In relation to this procedure, Willgoose stated:

> The average instructor should easily be able to pick out by inspection the primary component, and with little more difficulty, select the secondary component. Thus, the teacher should be able to tell whether a certain pupil is essentially a rugged mesomorphic endomorph, or a lean and energetic mesomorphic ectomorph. (47)

By utilizing the checklist published by Cureton (10c), the teacher or coach should soon find that she is fairly adept in assessing body structure.

Lateral Body Type (Endomorphic)
Morphological Characteristics

I. General Appearance	– Large, soft, bulging body
	– Thick body segments, anteroposteriorly
	– Mass concentrated toward center
	– Roundness and softness of body
	– Antero-posterior and lateral diameters tend toward equality in the head, neck, trunk, and limbs
	– Hair is fine and sparse
II. Segments	
1. Head, Neck, Face	– Large, round head
	– Short, thick, neck
	– Neck forms obtuse angle with chin in lateral plane
	– Wide, round face; wide, low palate
2. Thoracic Trunk	– Broad, thick chest
	– Wide costal angle
	– Some fatty breasts
	– Relatively straight spine
	– Postural defects of shoulders not common
	– Clavicular and scapulae hollows well padded

3. Arms, Shoulders, Hands	– Short arms, relatively – Short forearms, relatively – Limbs taper from "hammy" upperarms to small hands and wrists – High, square, shoulders – Smooth feminine musculature with no sharp muscle contours, viz.: deltoids and trapezeii – Short fingers, relatively
4. Abdominal Trunk and Pelvis	– Large abdomen, full above navel and pendulous – Long abdomen from sternum to pubis – Thick A-P depth at navel – Relatively straight lumbar spine
5. Legs, Feet, Buttocks	– Short legs, relatively – Heavy, fat buttocks with no dimpling or muscle outlines – Short forelegs, relatively – Heavy, "hammy" thighs – Large, smooth calves – Feet small and weakness common – Foot defects common

Heavy Athletic Body Type (Mesomorphic)
Morphological Characteristics

I. General Appearance	– A squareness and hardness of body – Rugged, prominent, massive muscles – Large, prominent bones – Transverse diameters of shoulders, forearms, and calves are large, but A-P diameters are less than in endomorphic types – Central concentration of mass is absent – Long and upright trunk, proportions variable – Skin is thick and coarse with conspicuous pores; holds good tan, small wrinkles infrequent – Hair is coarse, thick, or sparse
II. Segments	
1. Head, Neck, Face	– Head variable in size and shape but often cubicle with thick and dense bones – Facial bones are prominent, viz.: cheekbones, supraorbital ridges; square jaws – Facial mass great compared to cephalic mass – Fairly long, strong neck with great transverse diameter compared to anteroposterior diameter – Hair on head variable
2. Thoracic Trunk	– Predominates in volume over abdominal volume – Wide thorax at apex – Little thoracic curve in spine – Ribs – strong and heavy

3. Arms, Shoulders, Hands	– Shoulders seem low with trapezium and deltoidius muscles prominent – Broad shoulders – Clavicles heavy and prominent – Muscular upperarm, no "hamming" – Massive forearms, wrists, hands and fingers – Upperarm and forearm evenly proportioned
4. Abdominal Trunk and Pelvis	– Abdomen is large and heavily muscled ripples show – Slender, low waist – Pelvis sturdy and powerful with broad hips

Linear Body Type (Ectomorphic)
Morphological Characteristics

I. General Appearance	– Thin body segments, anteroposteriorly – Decentralization of structure – Linearity, thinness – Frail, delicate body structure – Small, thin-diameter bones – Undernourished appearance – Small trunk, long limbs – Profuse hair, baldness uncommon
II. Segments	
1. Head, Neck, Face	– Relatively large cranium – Bulbous forehead – Small face, pointed chin, sharp nose – Long, slender neck – Poke neck common – Lips delicate, thin, dry, pale – Abundant hair on head
2. Thoracic Trunk	– Narrow thorax, long compared to abdomen – Acute costal angle – Thin chest depth – Clavicular hollows marked, clavicles prominent – Winged scapulae, forward shoulders marked – Ribs prominent – Kyphosis, marked S-curve
3. Arms, Shoulders, Hands	– Long arms, relatively – Long forearms, compared to upperarm – Thin upperarms, muscles not marked – Shoulder droop and round shoulders marked – Thin forearms – Long thin hands – Inconspicuous knuckles
4. Abdominal Trunk and Pelvis	– Flat abdomen, hollow above navel – Short abdomen, protrusion common below navel – Thin anteroposterior depth at navel – Lordosis, marked S-curve

5.	Legs,	– Long legs, relatively
	Feet,	– Inconspicuous buttocks
	Buttocks	– Long forelegs, relatively
		– Thin thighs, muscles not marked
		– Calves relatively thin
		– Feet thin and long

To further facilitate the reader's ability to recognize the primary components, three silhouette drawings of common athletic somatotypes follow.

Figure 1 is a mesomorphic endomorph with a rating of 5 4 2; notice the round head, short, thick neck, broad chest, short waist, fat around the hips, and lack of space between the thighs. The mesomorphic endomorph should perform well in throwing events, volleyball, tennis doubles and in field hockey as a fullback or a goalkeeper; the individual with this somatotype is also successful in swimming in the distance events.

Figure 2 illustrates the physique of an endomorphic mesomorph; the somatotype is 4 5 2. The strength of the neck is apparent, as is the excellent shoulder breadth. The legs bow out, which is an indication of power. So many hockey players possessed this particular design of the legs that we came to call them "hockey legs." These sportswomen are able to accelerate and decelerate very rapidly. The endomorphic mesomorph is structured for sprinting and excels in activities where speed is an asset, e.g., hockey, soccer and track events.

In Figure 3, we see a more linear physique. The legs appear longer in relation to the trunk and are lighter in structure. The linearity is particularly noticeable in the forearms. Space between the legs is well marked. This athletic type does well in sports demanding agility and endurance, e.g., lacrosse, hockey defense, basketball and tennis. This balanced physique of 4 3 3 is fairly common among the women athletes.

In addition, by using the parameters of height and weight and the RPI, the physical educator may further objectify her ratings. The importance of height and weight as factors in performance has been discussed on page 119. On the RPI, high scores of 13 and above indicate linearity while those below 12 show ponderosity. Scores that fall between 12 and 13 do not clearly differentiate the types since the degree of fat and muscularity is unknown. Table 7 is included to facilitate the calculation of the cube root of the weight.

Another measure that is rather easily obtained is the ratio of height divided by abdominal thickness. The abdominal thickness is the anteroposterior diameter taken at the narrowest point which divides the abdominal trunk from the thoracic cavity. This ratio provides a supplementary tool for distinguishing the ectomorphic from the endomorphic build.

If a tape measure is handy (or improvised calipers) the teacher can measure the shoulder width — the distance between the outermost points of the shoulders, or the acromial processes. The hip width, or the measurement between the uppermost points of the pelvis (iliac crests), could also be assessed. The shoulder width to hip width ratio is an

important factor in physique. A score above 1.30 if combined with small stature indicates a build that is conducive to good performance in gymnastics, track and diving. A ratio of 1.25 and below is characteristic of hockey fullbacks/goalies, softball players and golfers. These are the athletes who must hit for distance.

The measurement from the midpoint of the buttocks to the bottom of the foot constitutes the leg length; the distance from the tip of the shoulder to the midpoint of the buttocks is the trunk length. If the leg length is divided by the trunk dimension, another essential bodily relationship may be found. A score above 1.63 on this ratio would favor runners, jumpers and gymnasts; a ratio below 1.58 is characteristic of hockey forwards and halfbacks and softball players.

Although strength as related to weight (or more precisely, leg strength as related to weight) is of proven validity in distinguishing the athletes, many physical education departments lack the necessary equipment for such measurements. Two alternative procedures are suggested as substitutes — the jump and reach test and the standing broad jump. Outstanding jumpers perform well in basketball, volleyball (tall stature), gymnastics and diving (small stature). Lower scores on these tests are usually associated with golfers, swimmers and softball players. Tables 8 and 9 provide *t* scores for the conversion of the raw scores; thus a broad jump of 78 inches falls at the mean of 50 on the *t* scale.

An appreciation of differences in body structure will also aid the physical educator in assigning grades more equitably. It is grossly unfair to expect the same level of performance from an endomorph as from a mesomorph. The possibility exists that it may be truly dangerous to attempt the conversion of an endomorph into a gymnast. Further, norms for standardized tests should reflect these variations in physique.

Health problems vary among body types, and the physical education instructor should be cognizant of this fact. Endomorphs are weak strength-wise. Also, their feet are usually small in relation to their body weight. Even at a young age, endomorphic students walk and run with the feet "toed out." This increases the area of the base but throws the weight on the medial borders; thus, the most vulnerable portion of the foot is subjected to greater pressure. Such students are often knock-kneed due to the oblique angle of the femur. Activities requiring excessive running and jumping, particularly on hard surfaces, must be excluded for endomorphic girls in order to reduce the wear and tear on their feet and knees. Swimming and bicycling would be far more suited to this type of body build. The ponderal group is considerably more susceptible to high blood pressure and digestive problems.

Girls of an ectomorphic physique are prone to respiratory ailments and nervous exhaustion. They are low on muscularity, and hence poorly designed for competitive activities. They require more rest than the average student, and, above all, an adequate diet. Ectomorphic girls must be properly attired to withstand inclement weather, and should not be permitted to swim for an undue length of time, particularly in cold water. Their lack of body fat predisposes them to respiratory infections, while

their low strength levels result in numerous postural defects. In the general school population, it is undoubtedly to the extremes in the distribution that we do the most damage.

CURRENT PROBLEMS AND PROJECTIONS FOR FUTURE STUDY OF PHYSIQUE

The pursuit of structural knowledge in this country is impeded by the lack of uniform methodology, instrumentation, terminology and systems of measurement. Important decisions must, therefore, be made to alleviate these problems.

1. Which somatotype method is most accurate and practical for future research?
2. Which type of fat caliper and devices for assessing strength should be used?
3. What system of measurement, the English or the metric, is most efficient for evaluating body structure?
4. What procedure should be used for movement annotation?

If we are to close the gap between our knowledge in this area and that in foreign countries, we must devote more research time to these problems. Obviously, a study of structure of the various athletic groups utilizing larger samples is a necessity. Each event must be analyzed in terms of structural as well as functional demands. Specific suggestions follow.

1. Longitudinal studies could be made relating to longevity, illnesses and injuries incurred by women athletes.
2. Bodily ratios, such as the crural index, the relation of upper arm to forearm measures, the RPI and abdominal thickness/height, could be investigated further.
3. Data could be programmed for computer use. A computer program is presently available for the Parnell system.
4. A centralized clearinghouse for the storage and dissemination of data related to women's athletics could be established.
5. A detailed study of the androgyny aspects of female performers could be conducted. We increase the stigma already associated with women athletes when we attribute their excellence of performance to male characteristics. Are we perhaps overlooking the possibility that this may be simply a human design for good motion? In Morris' study the woman with the highest andric rating was the mother of five children. Apparently her high rating on the male characteristics of physique in no way inhibited her biological accomplishments as a female.
6. Funds could be made available for additional research study.
7. Graduate students could be encouraged to pursue knowledge in the area of body structure and function.
8. Major departments could be urged to include courses in anthropometry and somatotyping.

With concerted effort and greater uniformity of attack, we should make great progress which will inevitably improve the quality of athletic performance in this country. We need to become more observant in our coaching, and, as Leonardo da Vinci once remarked, we must learn "to know how to see!"

Table 7
Cube Roots of Weight for Calculation of
Reciprocal Ponderal Index

Weight	Cube Root	Weight	Cube Root
100	4.642	125	5.000
101	4.657	126	5.013
102	4.672	127	5.027
103	4.687	128	5.039
104	4.703	129	5.052
105	4.718	130	5.066
106	4.733	131	5.078
107	4.747	132	5.092
108	4.762	133	5.104
109	4.777	134	5.117
110	4.791	135	5.130
111	4.806	136	5.143
112	4.820	137	5.155
113	4.835	138	5.168
114	4.849	139	5.180
115	4.863	140	5.192
116	4.877	141	5.205
117	4.891	142	5.217
118	4.905	143	5.229
119	4.919	144	5.241
120	4.932	145	5.254
121	4.946	146	5.266
122	4.959	147	5.278
123	4.973	148	5.289
124	4.987	149	5.301

Weight	Cube Root	Weight	Cube Root
150	5.313	161	5.440
151	5.325	162	5.451
152	5.337	163	5.463
153	5.348	164	5.474
154	5.360	165	5.485
155	5.372	166	5.496
156	5.383	167	5.507
157	5.395	168	5.518
158	5.406	169	5.528
159	5.417	170	5.540
160	5.429	171	5.550

Weight	Cube Root	Weight	Cube Root
172	5.561	185	5.698
173	5.572	186	5.708
174	5.582	187	5.718
175	5.593	188	5.728
176	5.604	189	5.738
177	5.614	190	5.748
178	5.625	191	5.758
179	5.635	192	5.768
180	5.646	193	5.778
181	5.656	194	5.788
182	5.667	195	5.798
183	5.677	196	5.808
184	5.687	197	5.818

Table 8
Jump and Reach Test*

Raw Score	*t* Score	Raw Score	*t* Score
24.0	85	16.0	54
23.5	84	15.5	52
23.0	82	15.0	50
22.5	80	14.5	48
22.0	78	14.0	46
21.5	76	13.5	44
21.0	74	13.0	42
20.5	72	12.5	40
20.0	70	12.0	38
19.5	69	11.5	36
19.0	68	11.0	34
18.5	64	10.5	32
18.0	62	10.0	30
17.5	60	9.5	28
17.0	58	9.0	26
16.5	56	8.5	24
		8.0	22

*Scores above 24 in. or below 8 in. interpolate *t* score.

Table 9
Broad Jump Test*

Raw Score	*t* Score	Raw Score	*t* Score
100	84	92	70
98	82	91	69
97	80	90	67
96	78	89	65
95	76	88	63
94	74	87	62
93	72	86	61

Raw Score	*t* Score	Raw Score	*t* Score
85	60	72	42
84	59	71	40
83	57	70	38
82	55	69	37
81	53	68	36
80	52	67	35
79	51	66	33
78	50	65	32
77	49	64	30
76	48	63	29
75	46	62	28
74	45	61	26
73	44	60	25

*Scores above 100 in, or below 60 in, interpolate *t* score.

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Carter, J. Somatotypes of college football players. *Research Quarterly* 39:467-481, Oct. 1968.

Laubach, L. and Marshall, M. A computer program for calculating Parnell's anthropometric phenotype. *Journal of Sports Medicine and Physical Fitness* 10:217-223, Dec. 1970.

ANNOTATED BIBLIOGRAPHY: BIOMECHANICS

Marlene Adrian
Washington State University
Pullman

Anderson, Jean P. An electromyographic study of ballistic movement in the tennis forehand drive. Ph.D. dissertation, Univ. of Minnesota, 1971.

Women representing three levels of tennis skill were subjects for a combined electromyographic and cinematographic study to investigate muscle action potential of varying degrees of ballistic movement. Eight muscles of the arm and shoulder were studied while the subjects performed a forehand drive using a stroke developer. Results indicated that there was quite a variation in muscle activity between subjects and between skill levels. It appeared that efficiency for the skilled players resulted from a decrease in muscle activity rather than the complete absence of muscular tension. Also, greater velocity of the forward arm swing showed no apparent relationship to a decrease in muscular activity.

Arnold, Gail B. An electrogoniometric study of the degree of movement of the wrist joint during the golf swing. M.S. thesis, Univ. of Massachusetts, 1968.

Movement in the left wrist joint was measured for 22 beginning and advanced female subjects using the driver and the five-iron. Results indicated that there were significant differences between the novice and the advanced groups at the address position, the top of the backswing, and impact while using both clubs.

Atwater, Anne E. Cinematographic analysis of overarm and sidearm throwing patterns. Ph.D. dissertation, Univ. of Wisconsin, 1968.

Skilled male and female subjects were filmed by side, rear, and overhead cameras and the films were analyzed to identify similarities and differences between overarm and sidearm throwing patterns. Results indicated that the inclination of the trunk differed significantly and this affected the height of the ball release. However, for both types of throws, the timing and sequence of many joint actions were very similar.

Brennan, Linda J. A comparative analysis of the golf drive and seven-iron shot with emphasis on pelvic and spinal rotation. M.S. thesis, Univ. of Wisconsin, 1969.

Five female competitive golfers were filmed while performing the two golf strokes. Cinematographical analysis indicated several similarities in the two strokes, including pelvic and spinal rotation in the backswing, wrist action, inclination of the club shaft and inclination of the trunk. Some differences were also noted, including pelvic action in the downswing, velocity of the clubhead and hip position at contact.

Broer, Marion. Patterns of muscular activity in selected sports skills. In *Abstracts of Research Papers.* Washington, D.C.: AAHPER, 1966.

One highly skilled adult female served as the subject. She performed 13 sport skills while muscle activity was recorded for 68 muscles by means of electromyography. The skills included throwing, badminton and tennis strokes, batting, volleyball, basketball, bowling and golf skills. Several similarities in muscle activity were noted for various skills, especially in the lower extremities.

Brush, Florence C. Patterns of movement and associated electrical muscle activity in college women of high and low motor ability. Ph.D. dissertation, Univ. of Maryland, 1966.

A kicking task was practiced and learned over 25 trials by subjects in the two different skill levels. Ink records were made for each trial to record horizontal force, knee joint movements in the backswing, the swing to contact and the duration and intensity of muscular activity. The results indicated that the two groups showed similar movement patterns, rates of learning and muscular activity with a few exceptions. Neither group showed a consistent or exclusive learning pattern over the 25 trials.

Collins, Patricia. A film analysis of selected swimming stroke kicks. Ph.D. dissertation, Univ. of Iowa, 1968.

Both male and female subjects were used in this study but calculations were made separately for each group. The female subjects were members of a university synchronized swim team. The flutter, side stroke, and breast stroke kicks were filmed by underwater and overhead cameras and the films were analyzed for various ankle, knee and hip measurements. Using rank order correlation, these results were compared with the swimmers' speed in the flutter and breast stroke kicks and their power in the sidestroke kick. Conclusions drawn from this study indicate: 1) less knee flexion and a greater range of motion characterized the faster flutter kicks; 2) greater hip flexion and range of hip movement of the top leg, extreme ankle extension of the bottom leg, and greater maximum spread at the knees characterized the more powerful scissors kick; and 3) technique difference was not related to speed in the breast stroke.

Cowmeadow, Marjorie. A comparison of bilateral muscle patterning and stability in the performance of the prone lying headstand. M.S. thesis, Univ. of Wisconsin, 1968.

Electromyographic recordings were made of six muscles of the arm and trunk and two-second serial photographs were taken of movement in the sagittal plane as the subjects performed the skill. The subjects' weight distribution during the performance was also recorded on a special center of gravity apparatus. The results indicated that the muscle patterning of this skill was repeated in all trials (six) for each subject. Also, it was found to be asymmetrical in the performance of this "symmetrical" skill.

Davis, Diane L. A cinematographic comparison of a volleyball spike performed with and without ankle weights. M.S. thesis, Univ. of Massachusetts, 1969.

One subject was filmed both with and without ankle weights while performing a volleyball spike. A film analysis for angular velocities and moments of force indicated that the subject followed a different pattern for the two different task conditions.

Eckert, Helen. Angular velocity and range of motion in vertical and standing broad jumps. *Research Quarterly* 39:937, Dec. 1968.

Male and female basketball players served as subjects for filming as well as for isometric extensor strength measurements of the hip, knee and ankle. Cinematographic analysis indicated that the hip showed greater angular velocity and range of movement in the broad jump whereas the knee and ankle showed greater velocities and ranges of movement in the vertical jump. The isometric extensor strength showed no relationship to angular velocities in either jump.

Eckert, Helen. Take-off variations in the standing broad jump. *Research Quarterly* 37:143, March 1966.

This study to determine the best take-off position for girls in the standing broad jump was made using ninth grade girls as subjects. The girls were given trial jumps having their toes even with the take-off board and with their toes over the take-off board. Each condition was tested with and without shoes. The results indicate that there is no advantage or disadvantage with shoes or without them. But the toes over the edge position, whether with or without shoes, appeared to be a significantly better starting position.

Grimes, Catherine Fay. A study of human performance in two dimension movement. M.S. thesis, Univ. of California at Los Angeles, 1962.

College women were filmed before and after a two-week self practice session in running forward, backward and laterally. Time from first indication of movement to the point when the center of gravity was over the starting line and then over the finish line was determined by final analysis. Most subjects improved their time in all runs. Many variations were noted in the subjects' preparations to perform each task.

Harding, Linda T. An electromyographic study of selected arm support activities. M.A. thesis, Univ. of Iowa, 1969.

Electromyography was used to determine relative action potentials for several muscles of the arm and upper body while the subject performed in the inverted position (handstand) and the upright position (straight arm support). Results indicated significantly more activity of the posterior deltoid and trapezius in the handstand position than in the straight arm support.

Heintz, Mara A. An electromyographic study of three digitations of the trapezius muscle in selected physical education activities. Ph.D. dissertation, Univ. of Iowa, 1969.

Several activities including grip strength, pullups, pushups, and the forehand and backhand strokes in badminton and tennis were performed while electromyographic recordings were made of the trapezius. Several significant differences were found. The action potentials in the overhand grip pullups were greater than in pushups; tennis stroke action potentials were greater than those in badminton strokes; and backhand strokes in both tennis and badminton revealed greater action potentials than those in forehand strokes.

Huber, Joanne C. The effect of skill improvement in the back walk-over on the response patterning of selected shoulder girdle musculature. M.S. thesis, Univ. of Wisconsin, 1967.

The electromyographic data from one highly skilled performer showed that the muscles were active when contributing to the movement and were quiescent when they were inessential. This served as a criterion and it was found that the other subjects showed inconsistent electromyographic recordings before learning the skill but tended to become more consistent during the 20 instructional periods as the subjects practiced and learned the skill.

Johnson, Joan. The tennis serve of advanced women players. *Research Quarterly* 28:123-131, May 1957.

Ten highly skilled women tennis players served as subjects to determine the relationship between speed and accuracy and to further analyze their serving movements. A stopwatch and films were used for the analysis. The court was specially marked for an accuracy score. The results indicated that there was no relationship between speed and accuracy of serve for this group. Analysis of the film showed consistency among the 20 trial serves of each subject, especially in the ball toss. Other elements of the serve such as grip, body rotation and arm extension were found to be related to accuracy in serving of all subjects.

Laird, Marie E. A comparison of selected mechanical characteristics of men and women while performing the long jump. M.S. thesis, Springfield College, 1969.

Maximum flexion and extension and angular velocity of hips, knees and ankles as well as speed at takeoff, time spent on the takeoff board and the distance of the jump were used to compare inexperienced men and women in a running long jump. Electrogoniometry with recordings on a physiograph were used to determine flexion, extension and angular velocities; special attachments to the physiograph were used to determine speed at takeoff time. The men recorded significantly longer jumps than the women subjects but the only difference in the other variables was found in the speed at takeoff time with the men being significantly faster than the women. Flexion, extension and angular velocities were not significantly different for this particular group of men and women subjects.

Lesh, Lona M. A kinematic and kinetic comparison of varying golf drive distances of a woman state champion. M.S. thesis, Univ. of Massachusetts, 1968.

Golf drives of 196 yards and 141 yards were analyzed by cinematographical methods to determine velocity, acceleration, vertical and horizontal forces and dominant muscle actions. It was found that heavier parts of the body such as the thigh and trunk were used more extensively in the longer drive. Also in the longer drive, there was better timing of successive body parts. All of these contributed to a greater club head velocity and thus to greater distance.

Lucey, Mildred A. A study of the components of wrist action as they relate to speed of learning and degree of proficiency attained in badminton. Ph.D. dissertation, New York Univ., 1952.

Using an apparatus designed by the author to measure angular velocity and range of movement of the wrist, an examination was made of the relationship between wrist action and acquisition of badminton skill. Skill was determined by various badminton tests and a round-robin tournament. The results indicate that wrist action is a factor but perhaps not as important as previously thought.

Oglesby, Billie F. An electromyographic study of the rectus abdominas muscle during selected gymnastic stunts. M.S. thesis, Washington State Univ., 1969.

Six female gymnasts served as subjects to help determine the function of the rectus abdominus muscle in the performance of selected gymnastic skills — handstand, front limbar, back bend, skip (on the beam), forward roll, kip (bars) and single leg shoot through. By means of electromyography, muscular action was determined for the upper, middle and lower portions of the muscle for all skills. Results indicated that the lower portion was most important followed by the upper and finally the middle portions of the muscle. Also the rectus abdominus was seen to perform a major function in five of the eight stunts although each stunt elicited a unique pattern of electrical activity.

Peiniger, Maribeth. A cinematographical analysis of women high jumpers. M.Ed. thesis, Pennsylvania State Univ., 1969.

Experienced female track and field participants served as subjects for a cinematographical analysis of fair and good high jumps. Running, transfer and takeoff velocities, angular velocity of the kicking leg, path of the center of gravity and selected time variables were determined. In these aspects of the high jump, no difference was found between the fair and good jumpers.

Rice, Mary A. An electromyographic study of specific muscles involved in the lacrosse cradle. Ed.D. dissertation, Temple Univ., 1969.

Electromyographic recordings were made of arm and hand muscles of skilled and semi-skilled lacrosse players performing the vertical and horizontal styles of cradling. Movies were also taken as the subjects performed. The analysis and conclusions were made in terms of the muscles involved in both top and bottom arms in each of the cradle styles for both the skilled and semi-skilled players. Some differences were found in the muscle activity between the different cradle styles and the top and bottom arms. However, no significant differences were noted between the skilled and semi-skilled players in the two styles of cradling.

Ross, Beverly. An electromyographic investigation of the presence and characteristics of the protective stretch reflex in the hamstrings. M.A. thesis, Univ. of Iowa, 1967.

Action potentials of three hamstring muscles were recorded and analyzed while the subjects performed various passive and active stretch activities. The occurrence of the protective stretch reflex was determined by a rise in the magnitude of the action potential toward the end of the stretch or a decreasing level of activity during a held stretch. The protective stretch reflex was observed in all three hamstring muscles occurring with the greatest magnitude in the active slow and active held stretch and least during the passive held stretch.

Rothstein, Anne L. The overarm throw in poorly skilled college women. In *Abstracts of Research Papers*. Washington, D.C.: AAHPER, 1970.

Eight subjects were filmed and their throwing pattern analyzed and rated according to a system proposed by F. Singer which classifies the sequence of movements in the overhand throw. It appeared that the subjects were at an arrested stage of development — at a point found to be a normal step in the development of the throw in children. It was suggested that the use of large balls in elementary school to the exclusion of small balls might have led to the pushing pattern observed in some subjects.

Rozzi, Louise Maria. A cinematographic analysis of the lacrosse cradle. M.S. thesis, Univ. of North Carolina at Greensboro, 1969.

Two subjects with different ability in the lacrosse cradle were filmed and also analyzed by lacrosse experts. Generally the cinematographic analysis was in accordance with the expert opinion. However, some differences were found between expert opinion and the film analysis, particularly in the position of the forearm and the crosse in relation to the ground.

Teeple, Janet B. A biomechanical analysis of running patterns of college women. M.S. thesis, Pennsylvania State Univ., 1968.

Films of the running pattern of 28 college women were analyzed for stride rate, angle of takeoff, touchdown, trunk lean, leg lift and time of support and nonsupport. These were correlated with maximum running velocity to determine if any of the variables were related to running ability. The effect of speed change on the biomechanical factors was also determined. Time of support was determined to be the primary factor associated with faster running ability. A change of speed in the run significantly altered stride rate and length, angle of leg lift and time of support.

Vanderbeck, Edna R. A cinematographic study of sculling patterns. *Abstracts of Research Papers*. Washington, D.C.: AAHPER, 1968.

Experienced synchronized swimmers were filmed and the films analyzed to determine if there was a common arm-hand pattern in their sculling. Angular displacement of shoulder and elbow, pronation and supination of upper arm and forearm and the sequence of these actions were determined. Except for the sequence of motion pattern involving the shoulder and elbow, a common pattern did not appear among the subjects.

Wolter, Carol. Comparison of measures of the elbow, radioulnar and wrist joints for fast, curve, and slow softball pitches. M.S. thesis, Univ. of Wisconsin, 1965.

Four skilled women softball pitchers performed the three different pitches while joint action was recorded by means of goniograms. Body position and ball velocity were also recorded. The results indicated that positioning of the wrist was variable while that of the elbow and radioulnar joints was similar except in degree. It was also found that the sequence of movement was not necessarily from proximal to distal and ball velocity was not directly proportional to the number of joints active at release.

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